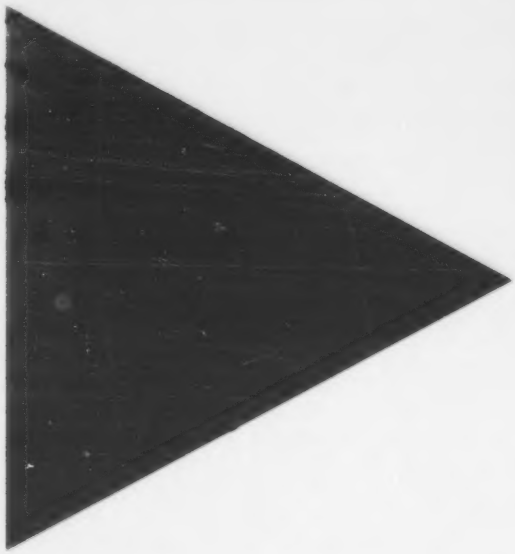
BEST PRACTICE GUIDE

BUILDING TECHNOLOGY



WOOD FRAME ENVELOPES

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Cette publication est aussi disponible en français sous le titre :
Enveloppe à ossature de bois–LNH 6922.

The Canadian Wood Council encourages the use of *Best Guide for Wood-Frame Envelopes* as a means of improving overall construction quality. The CAD drawings and explanations will contribute to a better understanding of building science issues that will assist designers and builders construct envelopes that are reliable, durable and economic.

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LIMITATIONS

Experienced professionals must review your use of the suggestions in this guide. Please keep the following points in mind as you read this information:

- This is simply a guide to current best practices for designing and constructing the building envelope for wood frame construction. It is not meant to replace professional advice.
- This guide provides a conservative interpretation of current state-of-the-art methods. It does not explore innovative technology that has not yet been field-tested.
- The materials and methods presented in this guide are not the only ones available. Many products and methods may be used as alternatives to satisfy regional differences, cost considerations, availability and special design demands.

This guide does not deal with

- preserved wood foundations,
- post and beam construction,
- prefabricated wall systems,
- doors and windows,
- roof systems,
- detailed energy and resource conservation strategies,
- fire and life safety design or
- structural design.

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CHAPTER 1

INTRODUCTION

PURPOSE OF THE GUIDE

Designers, builders, building owners and managers who consult this guide should gain a general understanding of the principles and practical considerations of designing and constructing wood frame envelopes. We have emphasized the best residential construction practice details and specifications used in design offices and on construction sites across Canada.

You may modify these details. You may also use them as standards against which to review technical issues in existing buildings. We hope that you will both use and develop the details you find in the paper and electronic forms of this guide.

HISTORY

Wood is the traditional, time-tested residential building material in Canada. Heavy-timber-braced frames were used in early construction. Log buildings were also common. In some cases, timbers were placed in direct contact with the ground. Builders soon developed a more durable practice where the wood framing material was supported on a timber sill, which in turn rested on a stone foundation.

Heavy timber construction methods gave way in the mid-1800s to balloon-framed construction. This consisted of a light frame of two-by-four lumber extending from the foundation to the roof, with the joists nailed to the studs and to ribbon boards. This system was made possible by the mass production of nails and the availability of large supplies of sawn lumber, and it sped up the construction process considerably.

Balloon-framed construction was replaced in the 1900s by today's wood frame construction, also known as platform-framed construction, in which each floor platform is framed separately on top of single-storey studs. This is the most efficient method of construction and makes use of standard pre-cut materials. One advantage of platform-framed construction is that shrinkage can occur evenly around the structure, without differential movement.

Sheathing materials evolved gradually from lumber boards to panel products such as plywood, fibreboard, waferboard, oriented strandboard (OSB) and other materials. Cladding materials also evolved from hand-split shakes to asphalt roofing and prefabricated siding products. The resulting building envelope became more weather-resistant and durable.

Energy-efficient and R2000 construction in the 1970s tightened up the building envelope by introducing improved insulation and air-barrier materials and techniques. This created better thermal performance and control of air leakage, it also meant that greater attention had to be paid to interior air quality and moisture management. The resultant moisture management techniques and materials, as well as improved building code enforcement and maintenance practices, have resulted in greater durability. In short, wood frame construction has performed well in Canada.

NOTICE TO DESIGNERS

DESIGNING DETAILS FOR WARM COASTAL AREAS

The details found in this publication may not be appropriate in all cases for warm, wet coastal areas such as Vancouver and the lower British Columbia mainland. Canada Mortgage and Housing Corporation's (CMHC's) recently published *Survey of Building Envelope Failures in the Coastal Climate of British Columbia* shows the type and extent of moisture problems in British Columbia's coastal climate for multi-family buildings where there are complicating factors, such as numerous openings for balconies and windows and a lack of roof overhang and face-sealed cladding. If you design for this or a similar climate, be sure to include features that reduce moisture entry into the envelope and allow exterior walls to dry out. Face-sealed claddings are particularly vulnerable. CMHC and the Building Envelope Research Consortium of British Columbia are now conducting further research to focus on the most problematic details for this type of climate and to test proposed solutions. The Best Practice Guide: Wood Frame Envelopes in Coastal Climate of British Columbia will be available in 1999.

DESIGNING INSULATED BASEMENT WALLS

This guide includes details that have proven to be effective for insulated concrete basement walls. The National Research Council of Canada, under the guidance of an industry steering committee that includes CMHC, is developing extensive guidelines for the design of insulated basements. This work includes reviews of physics, codes and standards, performance evaluations for exterior and interior insulation placements, and related aspects of below-ground construction. Its goal is to provide the tools designers need to select the most appropriate systems for their projects. Be sure to bookmark the Highrise and Multiples Innovation Group page on the CMHC Web site at www.cmhc-schl.gc.ca to keep up with research developments.

CHAPTER 2

WOOD IN CONSTRUCTION

Today's wood frame construction systems are the result of a long evolution. Changes have been driven by many factors, including the availability of materials and labour; product innovations such as sheet panels and prefabricated components; improved construction techniques; rising consumer expectations about the quality and utility of housing; migration of populations; and the pressure to use labour, materials and energy more efficiently.

Wood frame construction is the most common construction type used in Canada for single-family homes, row housing and low-rise apartment buildings. The National Building Code of Canada (NBC) permits builders to use wood to construct buildings up to four storeys high.

This chapter presents

- an overview of wood's characteristics as they affect building envelope design,
- a description of wood frame building assembly and
- a brief history of the wood frame building envelope.

CHARACTERISTICS OF WOOD

To use wood building materials successfully, you need to know something about the characteristics of wood–its directional nature and its ability to absorb, hold and react to moisture.

The type of wood that is most used for wood frame construction in North America is softwood, which is the product of coniferous (needle-bearing) trees. Softwood is plentiful and more easily worked and handled than other woods because of its light weight and machineability. In some cases, softwood even has a higher strength-to-weight ratio than hardwood.

DIRECTIONAL CHARACTERISTICS

Wood is composed of vertically aligned tubular cells or cellulose fibres that are generally aligned along the length of the tree (see Figure 2.1). The characteristics of the cells and fibres account for the differences in strength and shrinkage in lumber.

Wood is stronger along its length, since tree trunks support the crowns of the trees. For this reason, avoid positioning lumber so that forces pull in two directions across its width. Lumber also splits more easily along its length than across its width, so keep fasteners away from the ends a minimum of 25 to 50 mm (1 to 2 in.), depending on nail diameter.

Wood is more permeable along its length, reflecting the flow of water up the tree. As a result, lumber absorbs water more easily and dries out much faster at end-grain surfaces. Provide protection from liquid water at these surfaces.

However, wood absorbs water vapour across the grain. Wood cells shrink and expand mainly across their width, not their length, as they expel or absorb moisture (see Figure 2.2). They also contract and expand twice as much in the tangential (i.e., parallel to the circumference) as in the radial direction (see Figure 2.3). Lengthwise dimensional change is minimal and is generally ignored (see Table 2.1). The effect of wood shrinkage on the design and performance of wood frame building envelopes is examined in detail in Chapter 6.

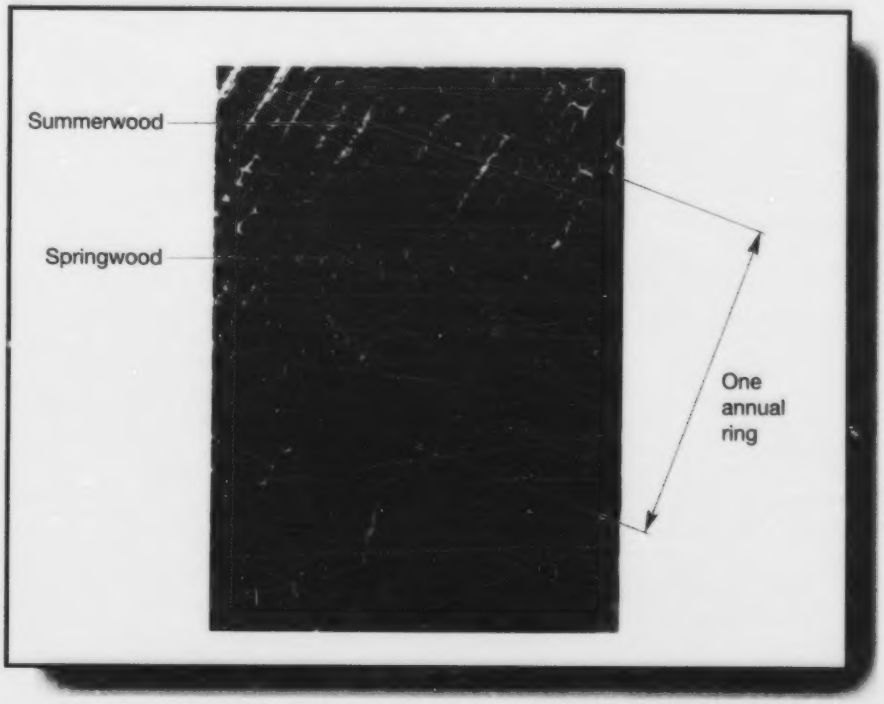


Figure 2.1: Cellular structure of wood

MOISTURE CONTENT

Moisture is held in wood in two places, the cell walls and the cell cavity. When timber is felled, it is highly saturated with water and needs to be dried before it is used in construction. Moisture content (MC) is the weight of water contained in the wood, expressed as a percentage of the weight of oven-dry wood. The term "oven-dry" indicates that there is no moisture in the cell fibre or the cell cavity. Kiln and sometimes air drying are used to obtain surfaced dry (S-Dry) grades of lumber. S-Dry lumber indicates that at the time of surfacing (also known as "dressing" or "planing") the wood had no more than 19 per cent moisture content. In comparison, surfaced green (S-Grn) grades of lumber have a moisture content of more than 19 per cent when surfaced. The physical characteristics of lumber are identified using grade stamps (see Figure 2.4).

The cell cavities are the first to dry as water leaves the wood. The "fibre saturation point" occurs when the cell cavities are empty, but the cell walls are still saturated, usually at about 28 per cent MC (see Figure 2.5). Since wood expands and contracts in direct proportion to the amount of moisture contained in its cell walls, changes in dimension occur only below the fibre saturation point, when the cell walls begin to dry out.

The MC of wood frame structures in service is usually from six to 14 per cent. In this MC range, wood will last for hundreds of years. If water migrates into a wall assembly from the interior or the exterior of a building and becomes trapped there, the MC of the framing lumber may increase above this range. In extreme conditions, the MC of lumber may reach a point where fungal growth occurs and the wood begins to decay (above 20 per cent MC). The transfer of moisture from inside or outside a completed dwelling into the building envelope is discussed in Chapter 4. Chapter 5 reviews how to manage moisture from various sources, including air leakage, vapour diffusion and rain penetration.

Table 2.1: Shrinkage of Green Wood

		Shrinkage (per cent) of Green Wood to:			
		19%	**15%**	**12%**	**6%**
RED CEDAR (WESTERN)	radial	0.9	1.2	1.4	1.9
	tangential	1.3	2.5	3	4
DOUGLAS FIR (COAST)	radial	1.8	2.4	2.9	3.8
	tangential	2.5	3.8	4.6	6.1
DOUGLAS FIR (INTERIOR)	radial	1.4	1.9	2.3	3
	tangential	2.5	3.4	4.1	5.5
HEMLOCK (WESTERN)	radial	1.5	2.1	2.5	3.4
	tangential	2.9	3.9	4.7	6.2
LARCH (WESTERN)	radial	1.7	2.2	2.7	3.6
	tangential	3.3	4.6	5.5	7.3
PINE (EASTERN WHITE)	radial	0.8	1	1.3	1.7
	tangential	2.2	3	3.7	4.9
PINE (RED)	radial	1.4	1.9	2.3	3.1
	tangential	2.5	3.6	4.3	5.8
PINE (WESTERN WHITE)	radial	1.5	2	2.5	3.3
	tangential	2.7	3.7	4.4	5.9
SPRUCE (EASTERN)	radial	1.5	2	2.4	3.2
	tangential	2.5	3.6	4.4	5.8
SPRUCE (ENGELMANN)	radial	1.4	1.9	2.3	3.1
	tangential	2.6	3.6	4.3	5.7

NOTES:

1. Tangential shrinkage applies to the width of the flat-grain face. Radial shrinkage applies to the width of the edge-grain face.
2. To calculate expected shrinkage determine the average equilibrium moisture of wood for end use conditions.

If you implement appropriate measures based on a good understanding of these concepts, you will ensure that the moisture content of wood will remain in a suitable range and that the structure will endure for years to come.

WOOD FRAME CONSTRUCTION

The components of a basic residential wood frame structure are illustrated in Figure 2.6. Contemporary building practice also requires the presence of an air-barrier system and a vapour retarder.

Each storey of the wall framing is constructed using the floor framing as a working platform-this explains the origin of the term "platform framing." The roof structure commonly consists of prefabricated roof trusses with panel sheathing and a roofing material. The use of panel sheathing products such as plywood or OSB allows the floors, walls and roof to act as rigid plates or

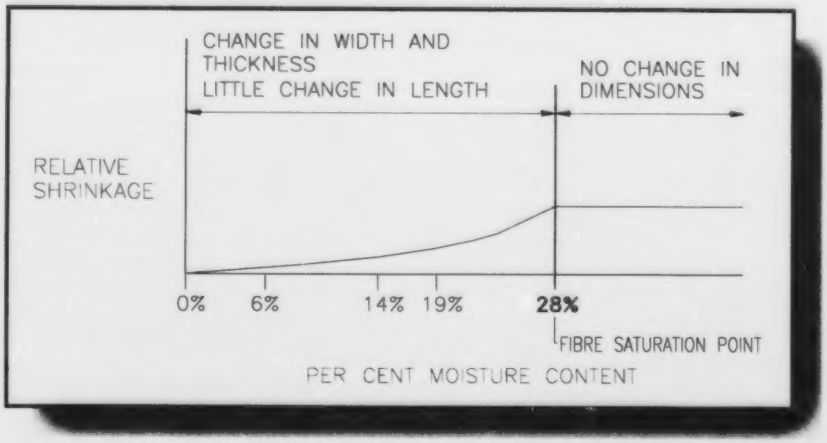


Figure 2.2: Wood shrinkage and moisture content

diaphragms. These components work in unison to resist racking, and they form a highly effective and resilient structure.

The building envelope must satisfy many functions: it offers structural resistance, thermal and acoustic insulation, weather protection, fire endurance and moderation of the interior environment. That is a significant challenge for any building system.

EVOLUTION OF THE BUILDING ENVELOPE

The main purpose of a building envelope is to keep the occupants of the building warm and dry. To meet this need effectively, designers and builders have modified aspects of the envelope over the past 100 years.

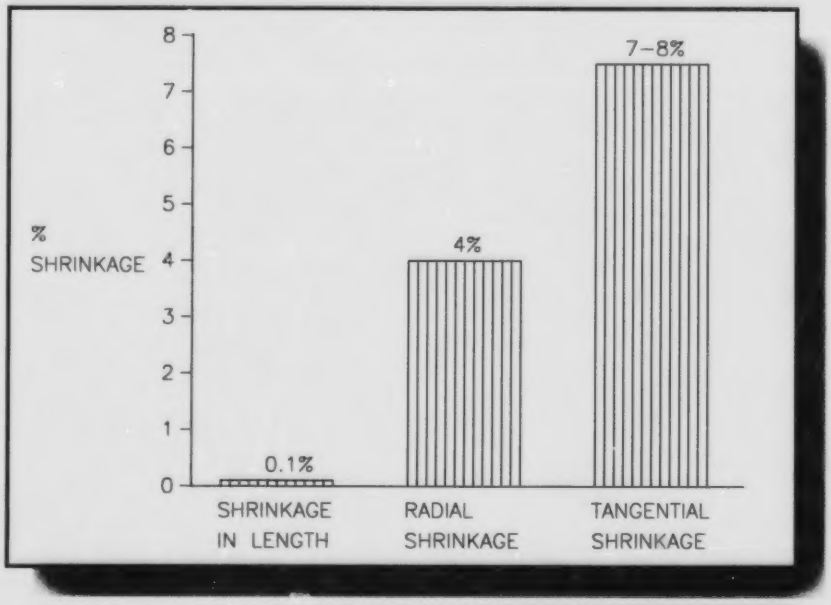


Figure 2.3: Directional wood shrinkage

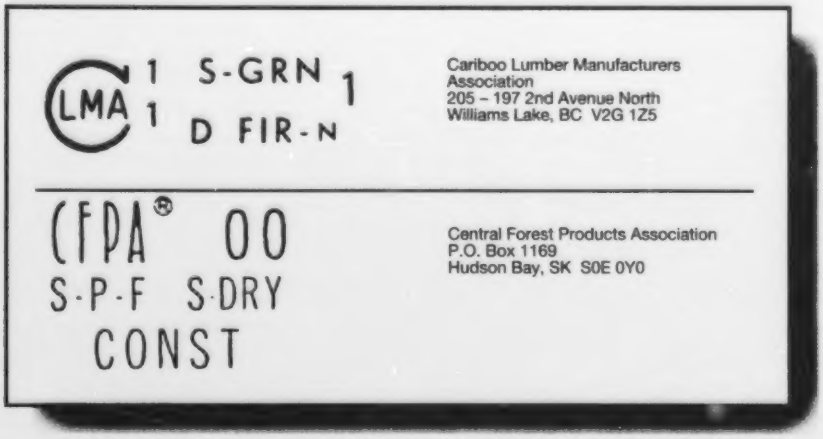


Figure 2.4: Grade stamps

The early balloon- and platform-framed houses were sheathed with 25-mm (1-in.)-thick boards on both the interior and exterior. The interior finish consisted of wood lath and plaster. Later, the interior sheathing boards were eliminated and the lath and plaster applied directly to the studs. Wood siding, shingles, stucco or brick were used for the exterior cladding.

A more nearly square plan for residential buildings was developed when central heating was introduced. This accommodated the heat distribution system from the central furnace. As insulation was added to the walls and roof, temperature and moisture gradients changed as well, placing new demands on the building envelope.

In the 1920s, the University of Saskatchewan showed that insulation was useful in reducing heat loss. Sawdust, seaweed, wood shavings and shredded newsprint were the available materials at that time. The use of manufactured insulating products whose components included straw, seaweed and mineral fibres spread during the 1930s.

Placing thermal insulation in the wall cavity reduced the temperature of the outer layers of the wall, leading to the problem of moisture accumulation due to condensation.

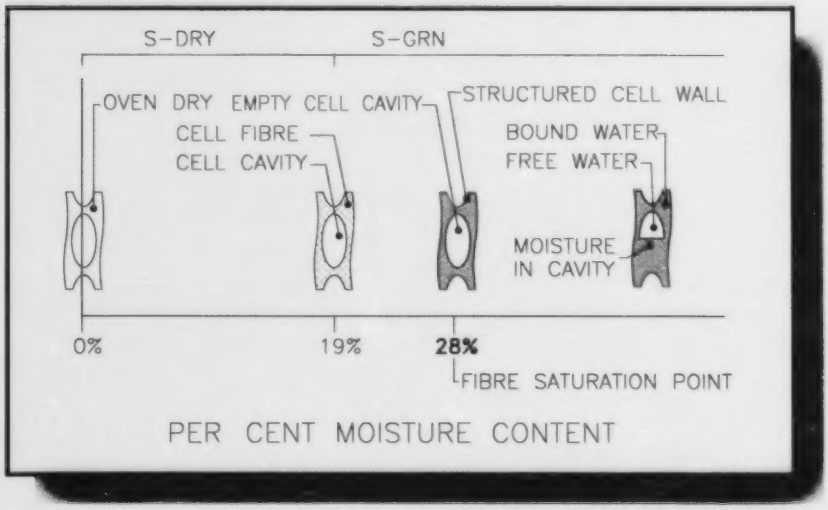


Figure 2.5: Fibre saturation point and wood

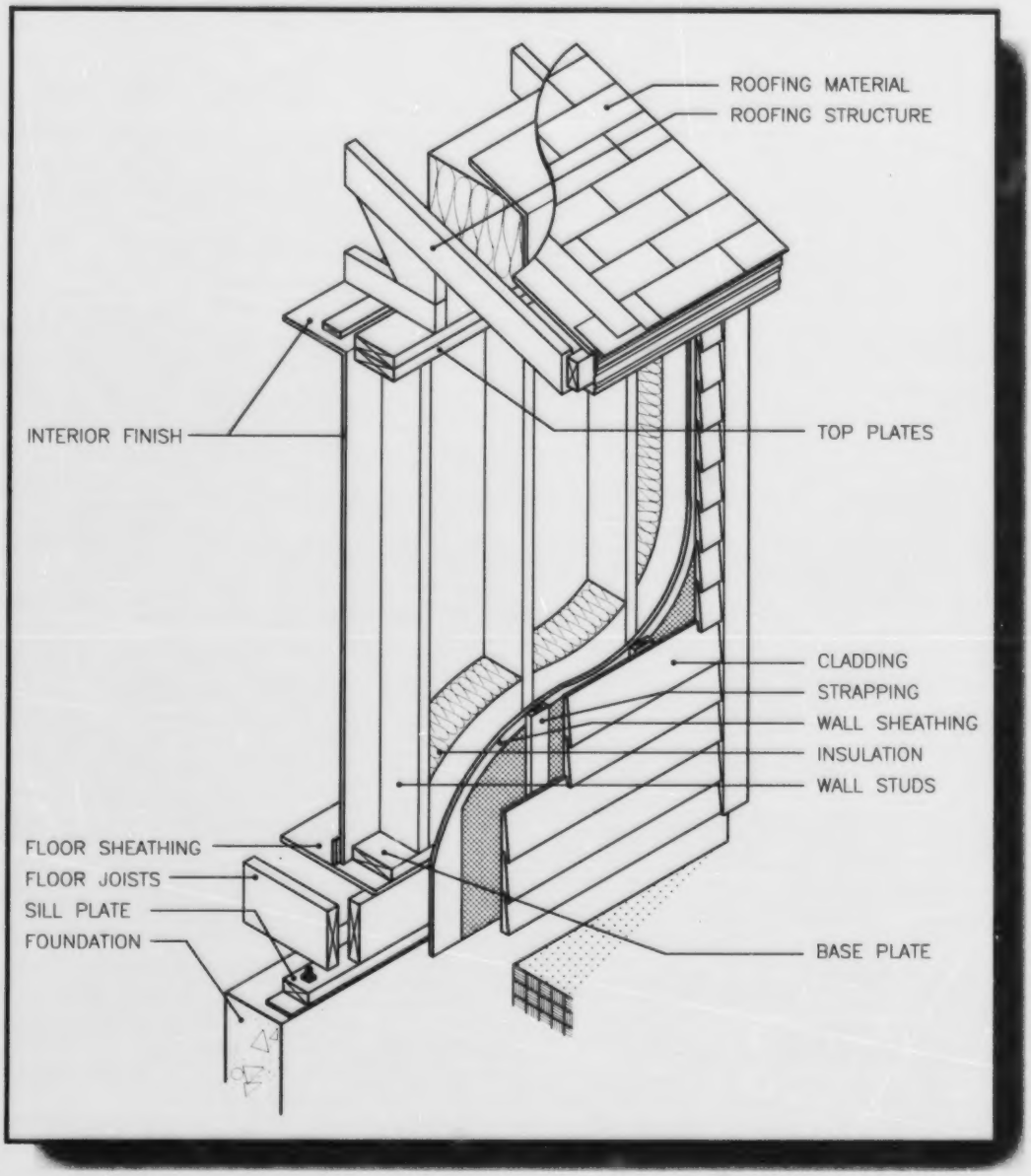


Figure 2.6: Components of a wood frame structure

Laboratory studies examined the movement of moisture through various building materials. It was determined that materials with a high resistance to moisture vapour would prevent condensation if placed on the warm side of insulation. Builders also began ventilating attics to dissipate accumulated moisture. By the mid-1940s, the use of insulation, a vapour retarder sheet (usually asphalt-covered kraft paper insulation facing) and attic ventilation were in widespread use.

The Canadian housing industry expanded enormously after the Second World War. The pressure to house more people more efficiently, along with the availability of new materials and techniques, led to the use of a number of new products and systems. Plywood and fibreboard sheathing and gypsum wallboard all came into widespread use in the 1940s, replacing plaster and

board sheathing. This improved the vapour resistance and airtightness of the wall assembly.

In the 1950s, prefabricated roof trusses and cladding materials gained acceptance. Each of these products significantly reduced the amount of labour used in construction and made more effective use of raw materials. They also allowed greater flexibility in building design, raising the level of consumer expectations for housing performance.

The warmer interior temperatures of homes led to problems with condensation on windows. Air leakage through window assemblies was discovered to be the main reason for condensation on storm glazing, and sealed thermopane windows came into use. Since the 1960s, researchers have paid more attention to air exfiltration as the source of moisture within the building envelope. Before the 1960s, vapour diffusion was believed to be the reason that moisture condensed on surfaces in cold climates.

Initially it was thought that most exfiltration occurred around doors and windows, but in the 1970s researchers determined that about 70 per cent of the air flow was through cracks in wall and ceiling assemblies. Industry seminars and practice notes were used to promote the importance of airtightness for condensation control. It became recognized that buildings required both air barriers and vapour retarders. Such materials as polyethylene fulfil these functions. In low-rise wood frame construction, polyethylene can act both as an air barrier and a vapour retarder (see details for Wall Assembly A in Chapter 7). Alternatively, drywall may be used for the air barrier and vapour-barrier paint as the vapour retarder (see details for Wall Assembly B in Chapter 7). Air leakage control was vigorously developed in the late 1970s by the National Research Council's Division of Building Research.

During this period there was also a move to disseminate information on rain penetration and the "open rainscreen" approach, which was based on principles developed by the Norwegian Building Research Institute and the National Research Council of Canada (NRC). Most of the emphasis was placed on high buildings, but the concepts were also subsequently applied to low-rise wood frame residential buildings.

In the early 1970s the price of oil increased dramatically and precipitated what was known as the "energy crisis." This became the most significant factor influencing building research technology and practice for more than a decade. Levels of insulation and airtightness in building envelopes increased substantially. By the early 1980s, changes in moisture and ventilation management had brought about the following concerns:

- High-efficiency furnaces and electric heating eliminated the chimney, which had typically induced a negative air pressure in homes. Without a negative pressure difference across the walls, it was more likely that air exfiltration would occur.
- Airtightening reduced air leakage. This meant that humidity generated by occupants' activities remained indoors.
- The higher level of indoor humidity increased the likelihood that condensation would form at leakage points in the building envelope.

Research on moisture and ventilation problems has continued to provide valuable information on envelope design criteria. Dissemination of this new information and corresponding changes to building codes continue to spur the evolution of wood frame building envelope design.

CHAPTER 3

HEAT TRANSFER

A typical Canadian house consumes 50 to 70 per cent of its total energy during the fall, winter and spring heating seasons.

Retaining heat is a primary function of the building envelope. Heat flow through a wall assembly from an area of a higher temperature to one of a lower temperature is a basic principle of physics. While the flow cannot be prevented, it can be controlled or slowed to decrease the total energy consumption of the building. Wood frame construction provides space to add insulation in order to slow heat loss.

This chapter examines

- the mechanism and control of heat transfer,
- thermal bridging, and
- thermal performance strategies.

HEAT FLOW

Heat is transferred through the building envelope in three principal ways:

CONDUCTION

Heat is conducted at the molecular level through the envelope materials. The rate of heat flow depends on the materials present. Every material has a different capacity to resist conductive heat flow, which is expressed as a metric Resistance System International (RSI) value or an imperial Resistance (R) value. The thicker the material and the higher its RSI value, the greater its capacity to resist heat flow.

CONVECTION

Heat transfer increases where convection currents are present in the assembly. The larger the space in the assembly, the greater the size of the loops, or currents, of air flowing through it. The effectiveness of such insulation materials as glass fibre, mineral fibre and cellulose are significantly reduced where there are convection currents. Eliminating voids in the insulated wall cavities will control heat loss by convection.

AIR LEAKAGE

When heated interior air leaks through the assembly, heat is lost directly to the exterior. An effective air-barrier system will substantially reduce this loss.

THERMAL INSULATION

Placing insulation in stud cavities and attics has been the primary means of controlling heat flow in wood frame houses. More recently, board insulations have been placed on the exterior of the stud wall assembly. The thermal resistance values of materials commonly used in wood frame construction are provided in Table 3.1.

You may base your choice of a cavity insulation on cost, availability and acoustic and thermal performance. Fibreglass, mineral wool and cellulose are the most commonly used insulation materials.

Table 3.1: Thermal Resistance

Material	RSI/mm	R/in.
Sheet Steel	NS	NS
Concrete	0.01	0.1
Lumber	0.009	1.3
Sheet Material		
Gypsum Board	0.006	0.9
Plywood	0.009	1.3
OSB	0.009	1.3
Insulating Fibreboard	0.017	2.5
Cavity Insulation		
Fibreglass	0.022	3.2
Mineral Fibre	0.024	3.5
Cellulose (Blown In)	0.025	3.6
Urethane Foam (Sprayed)	0.041	6.0
Board Insulation		
Rigid Fibreglass	0.029	4.2
Extruded Polystyrene (Types II & III)	0.034	5.0
Polyisocyanurate	0.034	5.0
Polyurethane	0.041	6.0

NS = no significant resistance

Sprayed cellulose insulation may contain water, which will raise the moisture content of the framing. Therefore, allow the wall cavity to dry before installing the interior vapour-barrier, and use a vapour-permeable wall sheathing. The potential for fungal growth due to the water is offset by the presence of fungicide in the spray application. The presence of fungicide should be verified with the manufacturer.

Sprayed urethane insulation is relatively vapour-impermeable and will not permit encased framing lumber to dry. This may result in fungal deterioration of the wood. Use dry lumber, and avoid encasing lumber when spraying this material.

THERMAL BRIDGING

Wood has a lower thermal resistance than the insulation materials that are used between the framing members. More heat flow will occur through these wood members than through the insulation (see Figure 3.1). This increase in thermal conductivity is referred to as

thermal bridging. Thermal performance of the wall assembly is reduced through thermal bridging.

Wood frame buildings rarely suffer from the condensation problems caused by thermal bridging in steel-stud-frame constructions. In wood frame buildings, condensation due to thermal bridging, which shows up as discoloration or mildew on interior wall surfaces, will generally occur only in the presence of all of the following factors:

- high interior humidity,
- poor circulation of interior air (pockets of low convection, usually found in the corners of rooms and at ceilings) and
- the presence of large masses of framing materials, such as multiple studs and plates, at corners of walls that lack insulated sheathing.

Typically, about 15 per cent of the wall area is framing material, depending on stud spacing and layout.

An increase in stud depth from 89 mm (nominal 4 in.) to 140 mm (nominal 6 in.) is now common in parts of Canada. It is a cost-effective way to increase thermal performance, but while it increases the depth of insulation, it does not overcome thermal bridging.

Various other strategies have been used to increase thermal performance and decrease thermal bridging. These "super insulation" systems (see Figure 3.2) include

- double stud walls with an insulation cavity between them,
- replacement of stud walls with trussed load-bearing members of greater depth,
- the addition of 38-mm or 64-mm (nominal 2 in. x 2 in. or 2 in. x 3 in.) horizontal strapping and insulation to one face of the studs and
- application of insulating sheathing to one face of the studs.

Insulating sheathings have proven to be the most cost-effective means of increasing thermal performance and decreasing thermal bridging. As a result, they are in widespread use. Note, however, that wood structural panel sheathing such as plywood or OSB provides greater resistance to wind or seismic loads and may be needed in addition to insulating sheathing products.

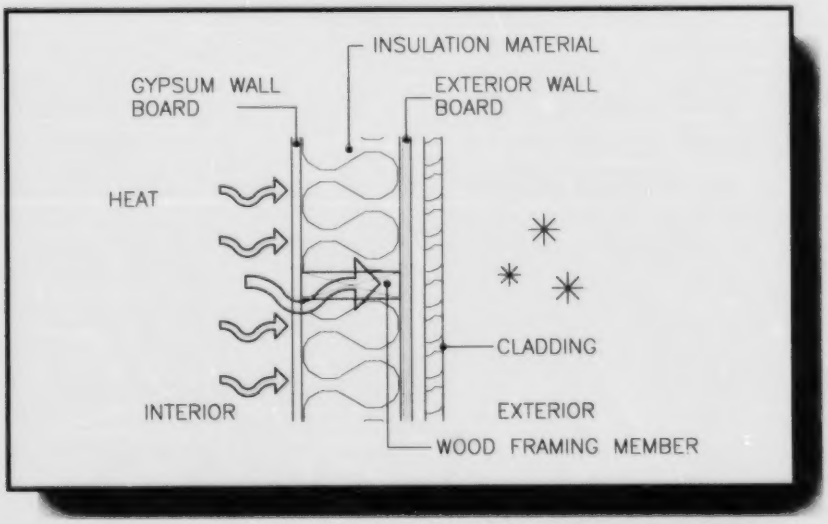


Figure 3.1: Thermal bridging

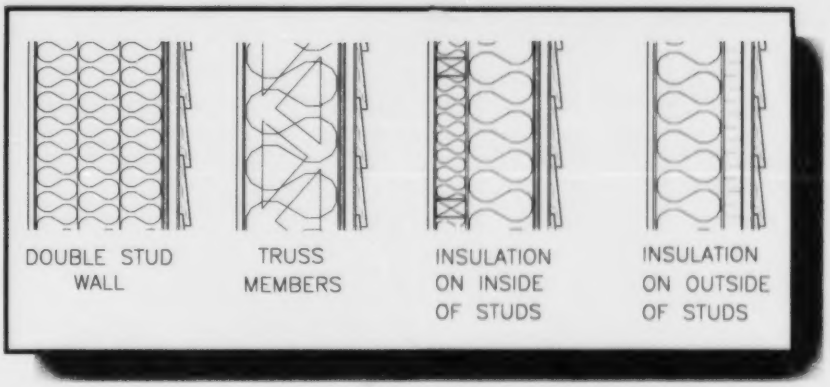


Figure 3.2: "Super insulation"

OPTIMIZING THERMAL PERFORMANCE

Energy-efficient home construction in Canada has been stimulated by the R2000 Home Program. This federal government initiative is administered by the Canadian Home Builders' Association. It has led to studies of the cost-effectiveness of various thermal performance strategies and the construction of up to 10,000 highly insulated homes.

One study undertaken in 1992 by CANMET, a division of Natural Resources Canada, and entitled "Incremental Costs of Residential Energy Conservation Components and Systems," established priority guidelines for improving thermal performance in two-storey houses. It was based on Winnipeg's local construction costs, energy costs and climate. The study listed those measures which had the greatest impact on thermal performance for the least cost. The priorities were these:

BASIC R2000 BUILDING

- Walls: Use 140-mm (nominal 6-in.) studs and RSI 3.52 (R-20) insulation.
- Basement walls: Use RSI 3.52 (R-20) insulation.
- Attics: Use RSI 7.04 (R-40) insulation.
- Airtightness: Use airtight construction.
- Use triple glazing.

First Upgrade Priority

- Increase basement wall insulation to greater than RSI 3.52 (R-20).
- Increase attic insulation to greater than RSI 7.04 (R-40).
- Use high-performance windows.

Second Upgrade Priority

- Add slab perimeter insulation.

Third Upgrade Priority

- Add slab centre insulation.
- Increase wall insulation to greater than RSI 3.52 (R-20).

Canada's new National Model Energy Code takes the process one step further and establishes energy performance requirements for buildings based on a cost-benefit analysis. The energy code, identified as a "model" code because provinces may choose whether to adopt it, considers the following criteria on a region-by-region basis:

- climate,
- fuel types,
- fuel costs and
- construction costs.

Unlike other energy codes, which generally do not account for thermal bridging when they prescribe insulation levels, this new code provides thermal performance levels that refer to the entire assembly, not simply to the value of the insulation found in the cavities.

CHAPTER 4

MOISTURE TRANSFER

The following mechanisms can cause moisture transfer through the building envelope:

- rain penetration
- uncontrolled air leakage
- water vapour diffusion

To manage this transfer properly, use the moisture control measures presented in Chapter 5.

SOURCES OF MOISTURE

Since the 1970s, increased airtightness in homes has created higher levels of interior humidity. That's because moisture cannot escape as readily as it did from the earlier, leakier houses. Moisture is added to Canadian homes by

- day-to-day living activities, such as breathing, cooking, bathing, washing and drying clothes;
- entry of moisture (rain or snow) through openings in the outer envelope of the building;
- the gradual release until a point of equilibrium is reached of moisture accumulated in building materials before and during construction;
- the gradual release in winter of moisture stored in wood furniture and building materials during warm, humid summer weather; and
- moisture migrating from soils through the basement walls or floor slab.

Airtightness must be carefully managed. While it helps to conserve energy and keep moisture out of the building envelope, without proper attention to air and moisture flows, airtightness alone can cause homes to be too stagnant and humid for comfort and long-term building durability.

The optimum humidity range in housing is 30 per cent to 40 per cent relative humidity (RH), when temperatures are kept in the 21°C to 23°C (70°F to 73°F) range. The RH values will be higher near cold surfaces, such as corners of exterior walls and especially at windows, than at the centres of rooms or near inside walls. When these local RH values reach 65 per cent, molds and bacteria can grow, while at local values of 55 per cent RH or more, dust mites can proliferate in upholstery and bedding. When indoor relative humidity drops below the 25 per cent range, the dry air irritates some people.

Wood frame houses, when properly constructed and maintained, will provide balanced relative humidity levels, thanks to wood's ability to store moisture. This ability allows wood to absorb water that would otherwise accumulate and cause damage to other wall materials. At the same time, wood releases water into the air when moisture is scarce, and increases humidity. Moisture in wood should be kept below 19 per cent to prevent deterioration.

MOISTURE MOVEMENT

Moisture is exchanged between the building envelope and the interior space throughout the year. These are the main ways moisture moves into the building envelope:

- Rain penetration–entry of moisture around the edges of and through penetrations in the exterior cladding

- Air leakage–the carrying of moisture through openings in or between materials
- Vapour diffusion–moisture movement at the molecular level through building materials

Rain penetration is a major source of moisture in houses. This source contributes more moisture than either construction moisture or condensation. This was shown in a recent survey of building envelope problems in a coastal climate. The amount of rain water that seeped into the buildings was determined by the quality of the design and construction of the exterior cladding. Moisture entered at edges and penetrations through the cladding, such as at windows, balconies, parapets and so on. The lack of roof overhangs also contributed to the problem. Water penetrated buildings where there were gaps or reverse laps in the building paper, or where the paper was missing.

Air leakage causes much more moisture to migrate outward into the building envelope than does vapour diffusion (see Figure 4.1). The following examples show that the rate of condensation due to air leakage is more than 100 times greater than the rate due to vapour diffusion through the wall.

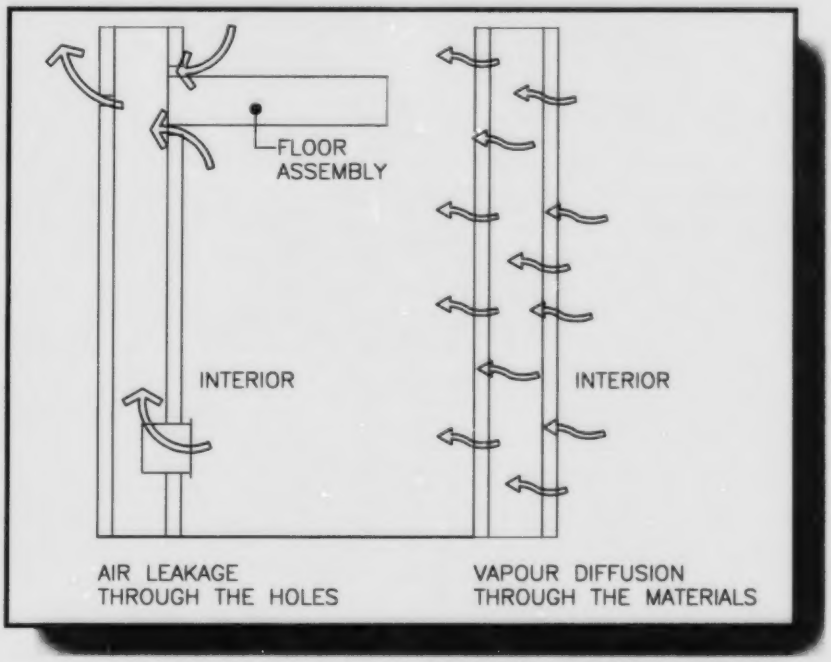


Figure 4.1: Air leakage and vapour d

Consider a typical exterior wall constructed of 38 x 89-mm (nominal 2 x 4-in.) studs with a Type II vapour retarder (water vapour permeance 60 ng/Pa•s•m^2 [1.04 grain/ft.^{2}/hr.] [in. Hg]) such as vapour barrier paint, and fibreglass batt insulation. At exterior conditions of -15°C (5°F) and 60 per cent RH and interior conditions of 21°C (70°F) and 58 per cent RH, moisture will condense within the cavity at a rate of ±4 g/m^2/day (±0.013 oz./ft.^{2}/day) due to vapour diffusion.

Suppose that indoor air exfiltrates through the cavity at a rate of ±1.4 L/m^2/s (0.028 gal./ft.^{2}/s.). (This is a realistic example for older buildings and is equivalent to an orifice flow induced by 10 Pa [0.0015 lb./in.^{2}] pressure

difference through a hole 20 mm [3/4 in.] in diameter.) The resulting rate of condensation will increase to 480 g/m²/day (1.57 oz./ft.²/day). When we compare this condensation rate due to air leakage with the vapour diffusion rate (condensation due to air leakage is 100 times greater than condensation due to vapour diffusion), we can see why it is essential that an effective barrier to air movement be present in the wall assembly.

The longer the path the air travels, the greater the amount of water that will condense in a wall assembly due to air leakage. If the path is short and goes directly through the wall (for example, at a crack below the base plate of a wall), a relatively small amount of condensation will occur. However, if the path is longer, there will be more time for the air to cool as it travels through the wall, and more condensation may occur.

Computer simulation of wall assembly performance can be used to model these processes. EMPTIED (Envelope Moisture Performance Through Infiltration, Exfiltration and Diffusion) is a software package that is available from CMHC for this purpose. It may be downloaded from the following Web site: www.cmhc-schl.gc.ca/research/highRise/files. The program incorporates data bases of the properties of different building materials and climatic information for geographic locations across Canada. The value of the program lies in its capacity to compare the expected performance of various assemblies. It can also predict to some degree the level of airtightness that is appropriate for different assemblies.

RAIN PENETRATION

Rain penetration is a common building envelope problem. The penetration of rain can damage finishes, insulation materials and framing materials.

All that is needed for water to flow into a wall is

- a film of water at the surface of the wall, or at the top or bottom of the wall,
- openings through which the water can pass and
- a force to move the water through the openings.

The elimination of any one of these three conditions will prevent rain penetration.

Preventing water from reaching the wall

Flat roofs with parapets need continuous end-sealed flashings with drips and other design features to keep water from running down the building face. While wide roof overhangs and flashings with pronounced drips help to shelter the walls of a building, reducing the incidence of problems, they cannot eliminate the presence of wind-driven water entirely. Deflection is an essential part of rain penetration control, but other strategies are also needed.

Eliminating openings which allow water penetration

The face seal approach attempts to eliminate all the openings in the outside face of the wall through which water can pass. Face seal systems do not typically depend on a single line of defence. There are secondary elements, such as flashing and sheathing membranes, that are used to intercept moisture that passes through the outer skin of the envelope.

Research has shown that rain penetration occurs mainly at the edges, not through the face, of the cladding. However, the materials used to surface and seal all of the openings are exposed to extremes of weather and the building's

movements. Even if design problems and job site inaccuracies can be overcome and a perfect seal can be achieved, the in-service weather conditions could eventually cause the deterioration and failure of these seals, creating openings in the wall through which water can pass.

Even an extensive maintenance program may not keep the building free of openings when there are many of them and they are difficult to identify. The success of the face seal approach depends on the design, the number of penetrations in the wall, the permeability and porosity of the cladding system, and the climate.

Forces Behind Rain Penetration

Rain penetration may also be controlled by dealing with the forces which drive or draw water into the wall. Four such forces are typically listed: kinetic energy, gravity, air pressure differences and capillarity. Each of these forces is explained below.

Kinetic Energy (see Figure 4.2)

Wind-driven rain droplets can be blown directly into openings in a wall. However, if there is no direct path to the interior of the wall, the rain droplets will not pass deeply into the wall. Where designed openings such as joints are unavoidable, the use of battens, splines, baffles or overlaps has been successful in minimizing rain penetration caused by the kinetic energy of the rain drops. However, unplanned openings can occur, unless the envelope is properly designed and constructed.

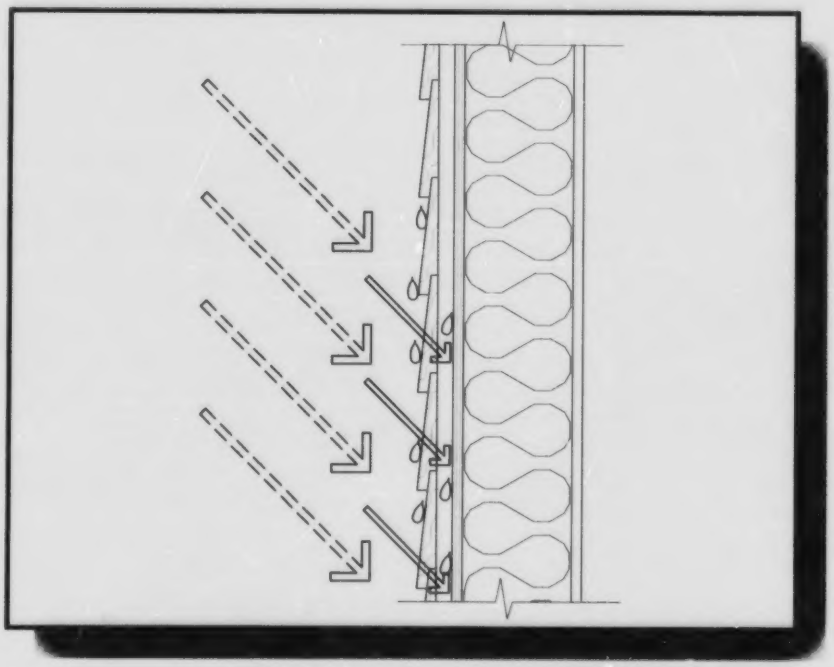


Figure 4.2: Penetration of wind-driven

Gravity (see Figure 4.3)

The force of gravity will cause water to move down the face of the wall and into any downward sloped passages into the wall. To prevent gravity-induced moisture problems, cladding units and back-up units such as sheathing membranes are lapped sequentially over units that are placed lower in the wall. In addition, the installer must ensure that there is an adequate slope of capping materials such as copings and sills.

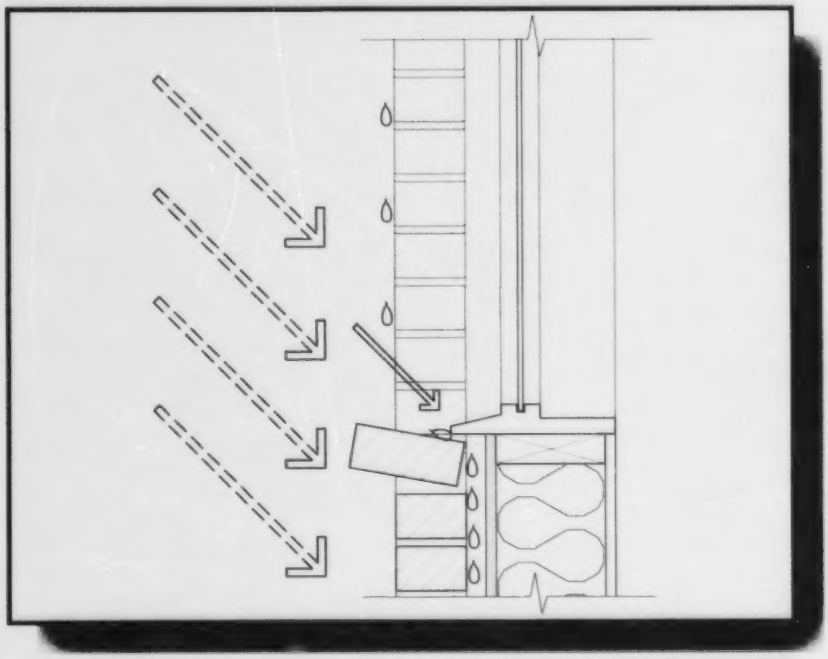


Figure 4.3: Rain and the effects of gravity

Unintentional cracks or openings are difficult to control. If there is a cavity directly behind the exterior face of the wall, any water that does flow through the wall can be directed downward, by gravity. At the bottom of the cavity, the water can then be drained back to the outside through the use of flashings and weepholes.

Air Pressure Differences (see Figure 4.4)

An air pressure difference across the wall of a building is created by stack effect, wind or mechanical ventilation. If the pressure on the exterior face of the wall is higher than it is on the interior of the wall, water can be forced through tiny openings in the wall.

Research has shown that this is the way that most moisture is moved through the cladding. This force can be eliminated or reduced by using a pressure-equalized cavity.

We therefore recommend using a pressure-equalized system (see "Application of Rainscreen Principles" in Chapter 5) where possible. Air pressure difference is explained further in the following section, "Air Leakage."

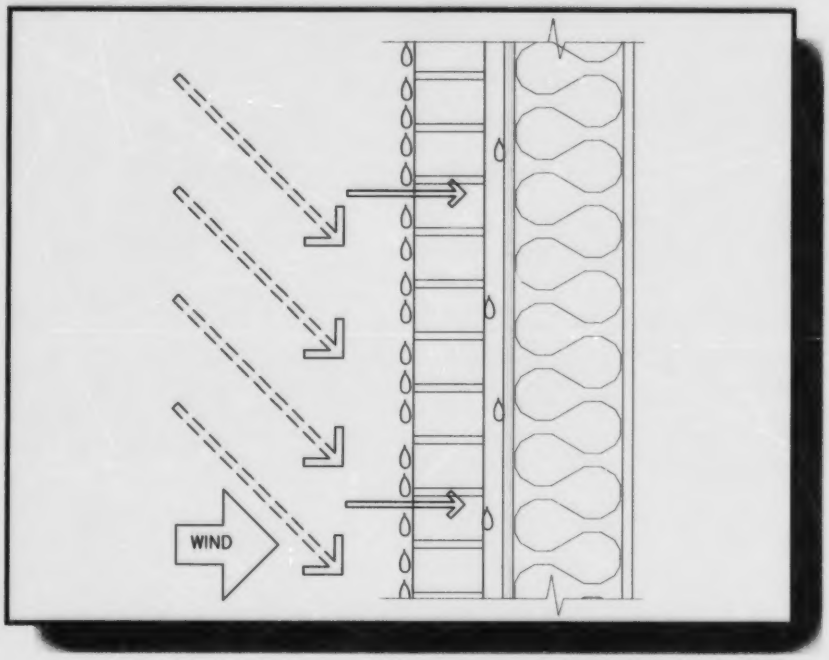


Figure 4.4: Air pressure difference

Capillary Action (see Figure 4.5)

Because of the surface tension of water, small gaps and fissures in a material will tend to draw and hold moisture. If capillaries pass from the exterior to the interior, as they do when porous cladding material is used, water can move through the wall by capillary action. An air space or cavity behind the cladding can prevent through-wall movement of water by this capillary action.

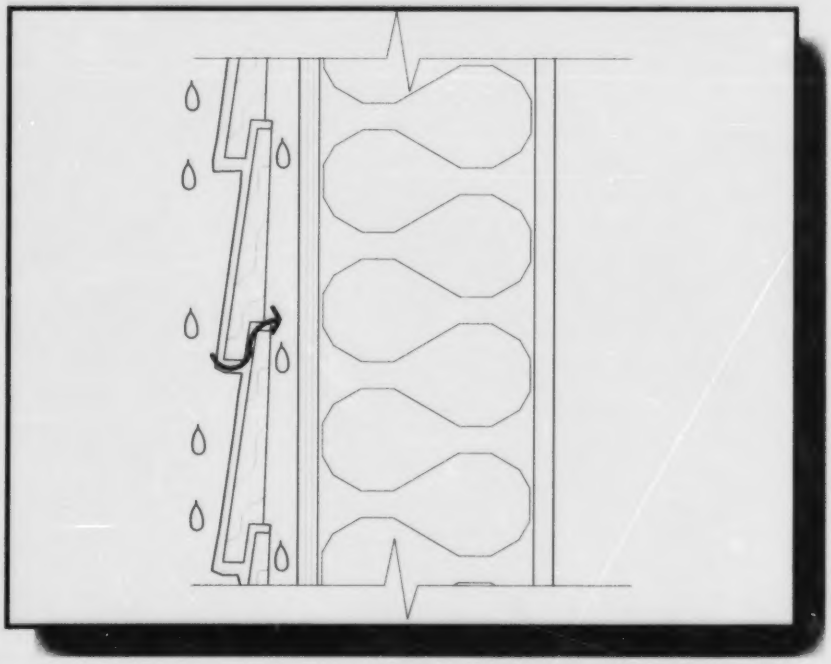


Figure 4.5: Capillary action

Examples include moisture uptake at the bottom of some insulation materials, or the drawing-in of moisture under window sills without drip edges. Moisture transfer by capillary action is usually minor, but it can be significant in localized areas.

AIR LEAKAGE

Air leakage is a function of two factors:

- gaps in the joints, junctions and materials of an assembly through which air can flow and
- a pressure differential between the inside and the outside of a building.

A pressure differential will occur because of

- wind,
- stack effect and/or
- mechanical exhaust.

Wind is a major source of pressure difference across the envelope. Positive pressure occurs on the windward side of the building, forcing air in through openings. At the same time, a negative pressure on the roof and leeward side will draw air out (see Figure 4.6).

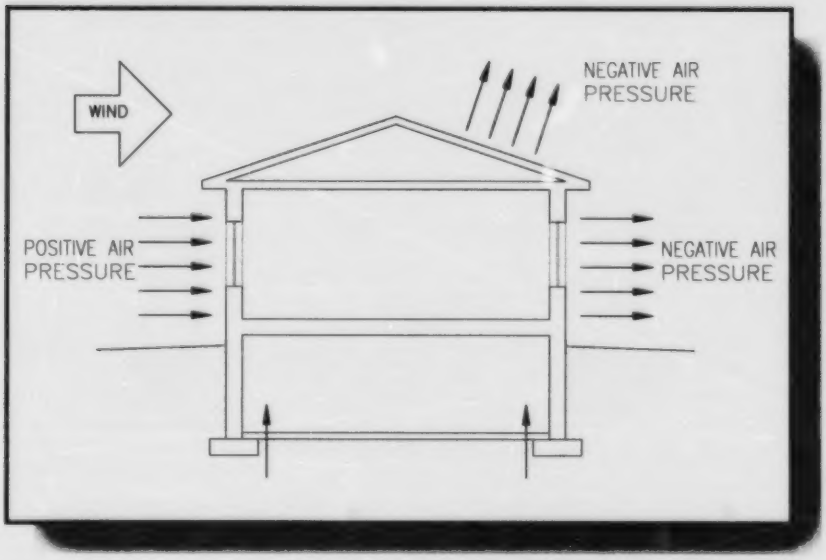


Figure 4.6: Air pressures caused by

As air is heated, it becomes less dense and rises. Stack effect is the positive pressure that forces air out of the envelope at ceiling and upper wall levels and draws cooler air in through the lower portions of the building (see Figure 4.7).

Mechanical exhaust through fans, chimneys and flues creates a negative pressure, drawing outside air in through openings in the building envelope (see Figure 4.8).

Air leakage will have other negative impacts on building performance, including

- occupant discomfort due to drafts,
- heat loss due to air leakage (the amount of heat lost in this manner can easily reach 25 to 40 per cent of a building's total amount of heat) and

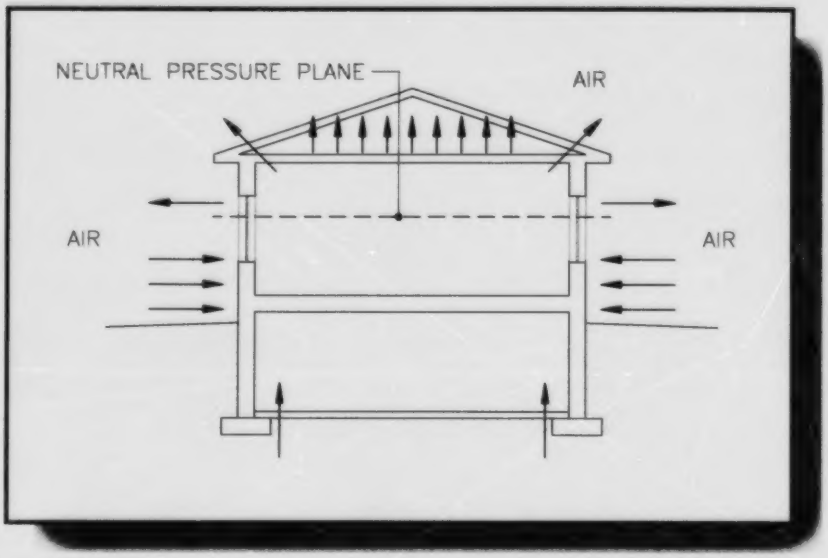


Figure 4.7: Stack effect and air leakage

- disabling of the rainscreen wall system, resulting in water penetration through the enclosure. This is explained in detail in the previous section, "Rain Penetration."

VAPOUR DIFFUSION

Diffusion is the movement of water vapour through a material from a location with a high water-vapour concentration to one with a lower water vapour concentration.

The vapour diffusion rate depends on the vapour pressure difference across the assembly and the vapour diffusion resistance of the materials in the assembly.

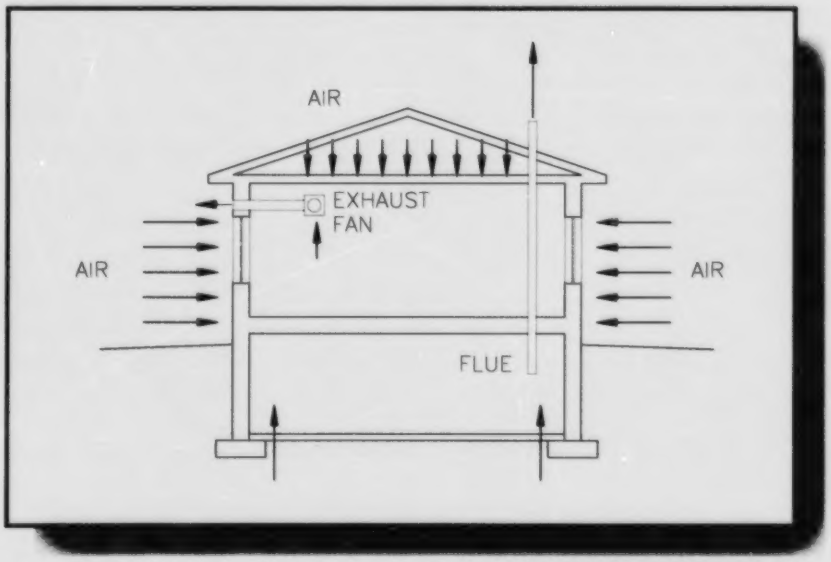


Figure 4.8: Mechanical exhaust creates a ***in through the building***

The vapour pressure difference across the assembly is a function of the temperature and relative humidity of the air on each side of the assembly. Of particular concern in cold climates is the vapour pressure difference across the assembly during winter, where water vapour pressure drives vapour from the moist warm interior to the cold, dry exterior.

GROUND WATER

Moisture can also migrate through foundation walls and basement slabs to the building interior. Where hydrostatic pressure is present in the soil, waterproof the foundation and slab. In less adverse conditions, control moisture by providing the following:

- good surface drainage at grade,
- moisture barrier on the ground at the bottom of the foundation (below the slab),
- a granular drainage layer below the moisture barrier and
- dampproofing on the foundation wall, etc.

Wood must be separated from concrete or masonry by a moisture barrier so that moisture is not drawn into the wood through capillary action. Acceptable materials include asphaltic coatings, asphalt-impregnated building papers and closed-cell gaskets.

CHAPTER 5

MOISTURE CONTROL

Design and construction details are essential to the long-term performance of the building envelope. The building envelope design must protect against all the moisture sources identified in Chapter 4. As mentioned in the previous chapter, in typical cold-climate housing, it is advisable to keep humidity levels at no higher than 40 per cent relative humidity to prevent condensation.

Many building materials are damaged by uncontrolled moisture. Interior finishes are subject to mold, mildew and deterioration in the presence of moisture. Brick veneers may spall if they remain wet during freezing winter temperatures. Steel will corrode in the presence of air and moisture. If kept dry, these materials will be durable.

During construction, moisture control begins with the proper handling and protection of materials on the job site. The design of the building must address details of deflection, drainage, drying and durability.

This chapter deals with

- protection of materials on the job site,
- moisture deflection,
- drainage,
- drying and
- durability.

MOISTURE IN CONSTRUCTION

Take the following precautions to keep wood dry on-site:

- Store wood close to the point of use and away from moisture sources such as damp ground and new concrete.
- Cover wood to protect it from standing water, rain or snow and from rapid re-drying by direct sunlight.
- Store wood flat and strapped in bundles. Where possible, use spacers between layers to promote ventilation.
- Roof and protect the building quickly after framing to minimize exposure to rain.

MOISTURE DEFLECTION

Moisture deflection refers to design and construction measures taken to divert unwanted moisture from entering the completed building envelope from outside or inside. This includes many design aspects of the outer envelope, such as roof coverings, overhangs, gutters and wall claddings. Deflection measures also include the incorporation of barriers and retarders into the wall construction that help to keep moisture from entering the wall. This section focuses on the latter aspects of moisture deflection: air barriers, vapour retarders and rainscreens.

AIR BARRIERS

The air-barrier system is intended to control unwanted air leakage. The system must comply with the following design requirements in order to function adequately:

- The air-barrier system must be continuous throughout the building envelope. It must span across dissimilar materials and joints and seal around penetrations.
- The air-barrier assembly must be structurally adequate to resist air pressure forces due to peak wind loads, sustained stack effect or fan pressurization from ventilation equipment.
- The air-barrier assembly must be sufficiently rigid to resist displacement.
- The total air-barrier assembly must be air-impermeable.
- The air-barrier assembly should have a long service life.

The NBC has further quantitative criteria for air-barrier systems for residential buildings that are more than three storeys high or that cover an area of more than 600 m^2 (6,450 ft^2), including the following:

- Sheet and panel materials providing the principal resistance to air leakage shall have an air leakage characteristic of not greater than 0.02 L/s-m^2 at 75 Pa (0.00041 Canadian gal./s.-$ft.^2$ at 0.01 lb./$in.^2$).
- An air-barrier system shall be designed and constructed to resist 100 per cent of the wind load specified for the geographic location in which it occurs.

For residential buildings of three storeys or less, and having an area not exceeding 600 m^2 (6 450 ft^2), which are regulated by Part 9 of the NBC, the air-barrier criteria are more prescriptive but do not give performance requirements in terms of maximum leakage rate. Part 9 requires that

- where the air-barrier system consists of an air-impermeable panel-type material, all joints shall be sealed to prevent air leakage;
- where the air-barrier system consists of flexible sheet material, all joints shall be sealed or lapped and clamped between rigid materials; and
- continuity of the air-barrier system shall be maintained where walls, floors and other penetrations extend through the envelope.

Initial efforts to achieve a satisfactory barrier to air movement in wood frame construction in the early 1980s focused on the use of polyethylene film acting as a combination air and vapour barrier. Laboratory testing and on-site analysis of polyethylene air barriers has raised a number of concerns. These can be summarized as follows:

- Wind and gust loading on polyethylene before the interior finish is installed can be sufficient to pull it off its fasteners. Perforations in the polyethylene may not be noticed or repaired before they are covered.
- Deterioration of the polyethylene, which may occur during the life of the building, cannot be seen and is unlikely to be repaired.
- Changes have been made to polyethylene to strengthen it and make it more heat- and UV-stable. Thicker, 0.15-mm (6-mil.) material, which is more difficult to seal effectively at overlaps and corners, is now used.

Numerous materials have a low permeability to air leakage (see Table 5.1). The joints of the material, as well as the material itself, must be capable of staying airtight under applicable wind loads.

Table 5.1: Air Permeability Rates of Selected Building Materials

Material	Rate		
	Metric	Imperial	
	Litres/second-metre^2 @ 75 Pa	Canadian (gallons/second-feet^2) @ 0.01 lb./in.^{2}*	U.S. (gallons/second-feet^2) @ 0.01 lb./in.^{2}*
Modified Bituminous Torch-on Membrane	NML**	NML	NML
Modified Bituminous Self-adhesive Membrane (1.6 mm) (1/16 in.)	NML	NML	NML
Plywood Sheathing (9.5 mm) (3/8 in.)	NML	NML	NML
Extruded Polystyrene (38 mm) (1 1/2 in.)	NML	NML	NML
Foil-back Urethane Insulation (25.4 mm) (1 in.)	NML	NML	NML
Foil-back Gypsum Board (12.7 mm) (1/2 in.)	NML	NML	NML
Plywood Sheathing (8 mm) (5/16 in.)	0.0067	0.000137	0.000114
Oriented Strandboard (15.9 mm) (5/8 in.)	0.0069	0.000141	0.000117
Gypsum Board MR (Moisture Resistant) (12.7 mm) (1/2 in.)	0.0091	0.000186	0.000155
Gypsum Board (12.7 mm) (1/2 in.)	0.0190	0.000389	0.000324
Particleboard (15.9 mm) (5/8 in.)	0.0260	0.000532	0.000443
Tempered Hardboard (3.2 mm) (1/8 in.)	0.0270	0.000552	0.000460
Spunbonded Olefin Film between 2 layers of 12.7-mm (1/2-in.) fibreboard	0.090	0.001840	0.001533
Fibreboard with Micro-perforated Polyethylene Facing	0.090	0.001840	0.001533
Expanded Polystyrene (Type 2)	0.124	0.002450	0.002042
Glass Fibre Rigid Insulation Board with Spunbonded Olefin Film, 1 Face	0.150	0.003060	0.002550

Table 5.1: Air Permeability Rates of Selected Building Materials

Material	Rate		
	Metric	Imperial	
	Litres/second-metre² @ 75 Pa	Canadian (gallons/second-feet²) @ 0.01 lb./in.²*	U.S. (gallons/second-feet²) @ 0.01 lb./in.²*
Spunbonded Olefin Film	0.960	0.019632	0.016358
Roofing Felt (13.5 kg [30 lb.])	0.190	0.003888	0.003242
Non-perforated Asphalt Felt (6.75 kg [15 lb.])	0.270	0.005520	0.004600
Perforated Asphalt Felt (6.75 kg [15 lb.])	0.389	0.007970	0.006642
Fibreboard (12.7 mm) (1/2 in.)	0.800	0.016360	0.013633
Perforated Polyethylene #1	4.030	0.082400	0.068667
Expanded Polystyrene (Type 1)	12.000	0.245331	0.204167
Tongue-and-Groove Planks	19.000	0.388440	0.323700
Glass Fibre Insulation	36.000	0.736000	0.613333
Vermiculite Insulation	70.000	1.431111	1.192592
Cellulose Insulation	86.000	1.758220	1.465183

Note: Concrete block does not have any air-barrier qualities.
* 1 Canadian gallon = 1.2 U.S. gallons
**NML = No Measurable Leakage

Unlike the vapour retarder in cold climates, the air barrier may be outside the insulation. However, if the air barrier is located on the outside of the wall, it must be permeable to water vapour to allow the wall to dry.

The NBC places restrictions on the use of materials having a low water-vapour permeance at the exterior of the envelope (see Table 5.2). It requires that materials with a water vapour permeance of less than 60 ng/Pa•s•m² (1.04 grain/ft.²/hr. [in. Hg]) be thick enough and insulative enough to ensure that their inner surface will remain relatively warm and not cause condensation if warm, moist air from the interior of a building leaks through the wall assembly and comes in contact with them.

In the case of wood sheathing products, the NBC requires that plywood and oriented strandboard (OSB) be installed with gaps between panels to permit drying of the assembly. These gaps are normally provided anyway to allow for panel expansion. Check the NBC for specific requirements. (Note: Do not use sheathing materials with a low water vapour permeability if the framing lumber has a high moisture content: they inhibit drying.)

ALTERNATIVE AIR-BARRIER SYSTEMS

Two different approaches to air-barrier systems are illustrated here and subsequently detailed in Chapter 7. These systems have been extensively

Table 5.2: Water Vapour Permeance of Common Materials*

Material	Water Vapour Permeance	
	Metric ng/Pa•s•m²	**Imperial** grain/ft.²/hr. (in. Hg) = a Perm
Vapour Retarder Membranes		
0.03-mm (1-mil) aluminum foil	negligible	negligible
0.15-mm (6-mil) polyethylene	1.6-5.8	0.027-0.10
0.10-mm (4-mil) polyethylene	3.4-5.0	0.059-0.087
0.05-mm (2-mil) polyethylene	7.0-13.0	0.12-0.23
Paints		
1 coat vapour retarder paint	2	0.45
1 coat alkyd sealer plus 1 coat alkyd low lustre	2	0.48
1 coat latex sealer plus 1 coat latex paint	147-257	2.56-4.48
2 coats alkyd paint on plaster	91-172	1.58-2.99
Insulation		
25-mm (1-in.) foil-faced polyurethane	negligible	negligible
25-mm (1-in.) extruded polystyrene (Types 3 and 4)	23-92	0.40-1.60
25-mm (1-in.) extruded polystyrene (Type 2)	60-200	1.04-3.40
25-mm (1-in.) expanded polystyrene (Types 1 and 2)	115-333	2.00-5.80
100-mm (4-in.) fibreglass batts	1 666	28.97
100-mm (4-in.) rock wool	1 807	31.48
50-mm (2-in.) fibreglass batts	2 000-2 600	34.84-45.30
Framing and Sheathing		
19-mm (3/4-in.) lumber	982	17.11
6-mm (1/4-in.) extruded plywood	23-74	0.40-1.29
11-mm (7/16-in.) OSB	44-200	0.77-3.48
12.7-mm (1/2-in.) asphalt-impregnated fibreboard	2 645	46

Permeability=Permeance x thickness of materials in inches
Perm x 57.5 = ng/Pa•s•m²
* Vapour permeance varies from manufacturer to manufacturer.
Designers should verify the permeance of selected materials with the manufacturer.

Table 5.2: Water Vapour Permeance of Common Materials*

Material	Water Vapour Permeance	
	Metric ng/Pa•s•m²	**Imperial** grain/ft.²/hr. (in. Hg) = a Perm
Framing and Sheathing *(continued)*		
38-mm (1 1/2-in.) fibreglass sheathing	30-1 723	0.52-30.02
12.7-mm (1/2-in.) gypsum board sheathing	2 860	49.82
12.7-mm (1/2-in.) foil-faced gypsum board	negligible	negligible
25-mm (1-in.) expanded polystyrene (Type 2)	86-160	1.49-2.78
25-mm (1/2-in.) foil-faced cellular plastic insulation	negligible	negligible
Breather-type sheathing paper	170-1 400	2.96-24.39
Spun-bonded polyolefin	3 646	63.51

Permeability=Permeance x thickness of materials in inches
Perm x 57.5 = ng/Pa•s•m²
* Vapour permeance varies from manufacturer to manufacturer.
Designers should verify the permeance of selected materials with the manufacturer.

tested and found to perform well under sustained wind loads and gust loads. A leakage of 0.1 L/s-m² @ 75 Pa (0.002 gal./s.-ft.² @ 0.01 lb./in.²) was the general criteria for acceptance of details in tests.

One system, known as the Airtight Drywall Approach (ADA), uses an air barrier located at the interior of the envelope and the other, the External Air Systems Elements (EASE) system, at the exterior. Their key features and characteristics follow. Other systems may also perform satisfactorily, and we do not preclude or discourage their development or use.

Airtight Drywall Approach (ADA)

The gypsum board and framing members provide the air barrier. Continuity between different materials is created with caulking or gaskets. Be sure to seal penetrations of the gypsum board made by electrical fixtures or other services.

An advantage of this system is that the drywall is exposed for inspection and maintenance at all times. Nail pops, cracks and other damage must be kept repaired over the life of the building (see Figure 5.1).

EASE: Air-Barrier Sheathing Approach

Several methods of achieving an air barrier with sheathing have been tested. The most suitable are those which are permeable to water vapour. The External Airtight Sheathing Element approach has been developed in response to this.

The EASE air barrier consists of spunbonded olefin sandwiched between two layers of fibreboard sheathing. At the ceiling level, the air barrier is created

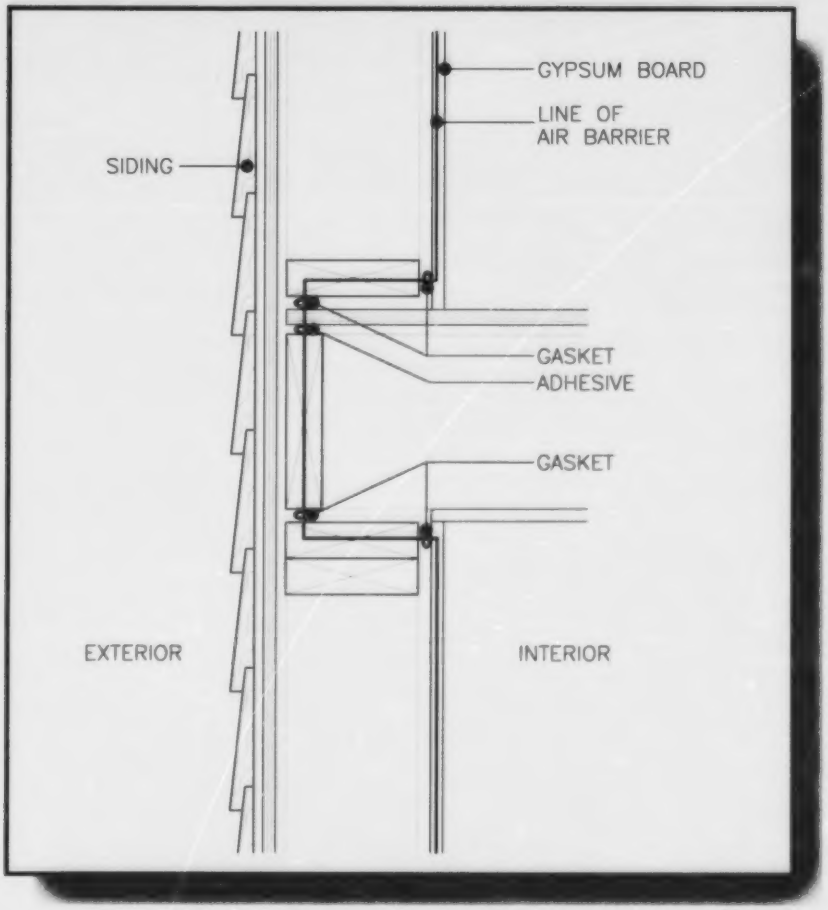


Figure 5.1: Airtight Drywall Ap

by sandwiching polyethylene sheet between gypsum board and fibreboard. (Alternatively, the ADA system can be used at ceiling level.) The advantage of the system is that penetrations of the interior wall finish for electrical outlets and disruptions such as stairs, plumbing fixtures and partitions do not affect the continuity of the air barrier (see Figure 5.2).

Regardless of which system or combination of systems is used, continuity must be maintained at joints and interruptions. Compensation must be made for movement in framing members due to the rate of initial drying or seasonal variations in moisture content. Select gasketing or sealants that accept these movements and will last the life of the assembly.

VAPOUR DIFFUSION RETARDERS

Construction materials have a moisture diffusion resistance measured by the inverse of their water vapour permeance. While vapour diffusion does not cause most moisture problems, difficulties can be significant if not addressed.

Select the vapour diffusion retarder based on the permeability of other materials in the assembly. Where low permeance cladding materials such as metal or vinyl siding, or sheathing such as plywood or OSB are installed with tight joints and without a vented space, a Type I vapour retarder, such as polyethylene sheet or aluminum foil, should be used. With such sheathing

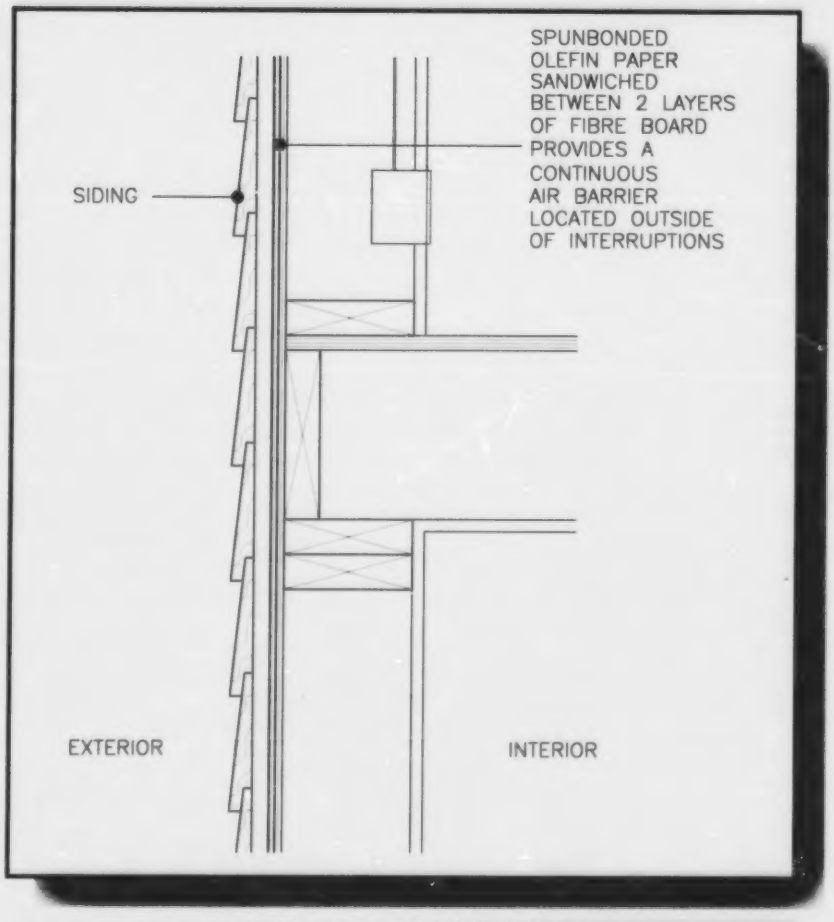


Figure 5.2: External Airtight Sheathing E

materials as laminated fibreboard or spunbonded olefin-faced fibreglass board that has a high permeability to moisture, a Type II vapour retarder such as vapour retarder paint is acceptable.

Where plywood or OSB is used for floor sheathing over an unheated space, it may not be necessary to install a vapour retarder as well.

As a rule of thumb, the exterior material should have a vapour permeance of 10 to 20 times that of the vapour diffusion retarder. Alternatively, base the selection of exterior materials' vapour permeance requirements on calculations, such as those of CMHC's EMPTIED computer program.

The maximum water vapour permeance of a Type I vapour retarder defined in CAN/CSA 2-51.33 is 15 ng/Pa•s•m^2 (0.26 grain/ft.^{2}/hr. [in. Hg]). This permeance level can be met by a broad range of materials, including polyethylene sheet, foil, metal and glass. A Type II vapour retarder has a maximum permeance of 60 ng/Pa•s•m^2 (1.04 grain/ft.^{2}/hr. [in. Hg]) or less before aging.

To control water vapour diffusion, install the vapour retarder on the warm side of the insulation materials, which is normally on the high vapour pressure side of the assembly.

The water vapour permeance of various materials is listed in Table 5.2.

Fibreboard sheathing, gypsum board and asphalt-impregnated fibreboard

sheathing have vapour permeance greater than 1,150 ng/Pa•s•m² (20 Perm) and are considered very permeable. In a 1992 study by D.M Burch and others, it was observed that permeance increases exponentially from a dry to a fully saturated state for exterior grade plywood and sugar pine lumber and ranges from "vapour retarder" to "very permeable." The moisture diffusivity of asphalt-impregnated fibreboard sheathing (density 399 kg/m³ [25 lb/ft³]) decreased when the moisture content exceeded three per cent. The researchers suggested that this might be because the dominant moisture transfer mechanism for the plywood and pine is bound-water diffusion, while for the asphalt-impregnated fibreboard, the principal moisture transfer mechanism may be vapour diffusion through air-filled pores.

APPLICATION OF RAINSCREEN PRINCIPLES

A pressure-equalized Rainscreen resists rain penetration in three ways: the outer cladding deflects the bulk of the rain water; a cavity allows water that passes the outer cladding to drain out; and the differential pressures across the cladding are equalized.

The theory of pressure-equalized cladding is that water penetration is reduced by neutralizing the air pressure difference across the cladding that is caused by wind or other forces. It is impossible to prevent wind from blowing on a building, but it is possible to counteract the pressure of the wind so that the pressure difference across the exterior cladding of the wall is close to zero. As the pressure difference across the cladding nears zero, one of the main forces of rain penetration is reduced.

Pressure equalization is achieved by using a Rainscreen wall, which incorporates two layers separated by a pressure-equalized, compartmentalized cavity. The air space is vented to the outside. When wind blows on the building facade, a pressure difference is normally created across the cladding; however, if the cavity behind the cladding is vented to the outside, pressure in the cavity increases until it equals the exterior pressure. This concept of pressure equalization requires that the inner layer of the wall be airtight. This inner layer, which includes the air barrier, must be capable of sustaining maximum wind loads in order for pressure equalization to occur. If there are openings in the air barrier system, the pressure in the cavity will not equalize, and rain may penetrate (see Figure 5.3).

The action of wind flowing around a building creates pressures and suctions distributed over the entire surface of the building. If the cavity is continuous, lateral flow of the air within the cavity is possible. In this situation, pressure equalization does not occur.

The cavity space must be closed at all corners of the building to maintain the pressure equalization on the windward face and to prevent air from being suctioned out on the adjacent wall faces (see Figure 5.4). An example of corner compartmentalization between brick cladding and siding is illustrated in Figure 5.5.

In multi-storey buildings, the cavity must be compartmented into spaces both horizontally and vertically. The most recent research indicates that compartment seals are needed at all corners and at the top of these buildings. In this edge zone, which is about 10 per cent of the building width, the compartments should be small, about 1 m to 1.2 m (3 ft., 3 in., to 4 ft.) wide. In the middle of the facade, compartments can be larger, from 10 m to 15 m (33 ft. to 50 ft.) wide and 6 m (20 ft.) high. Seals must be tight enough to prevent air leakage and strong enough to resist the applied pressure. In

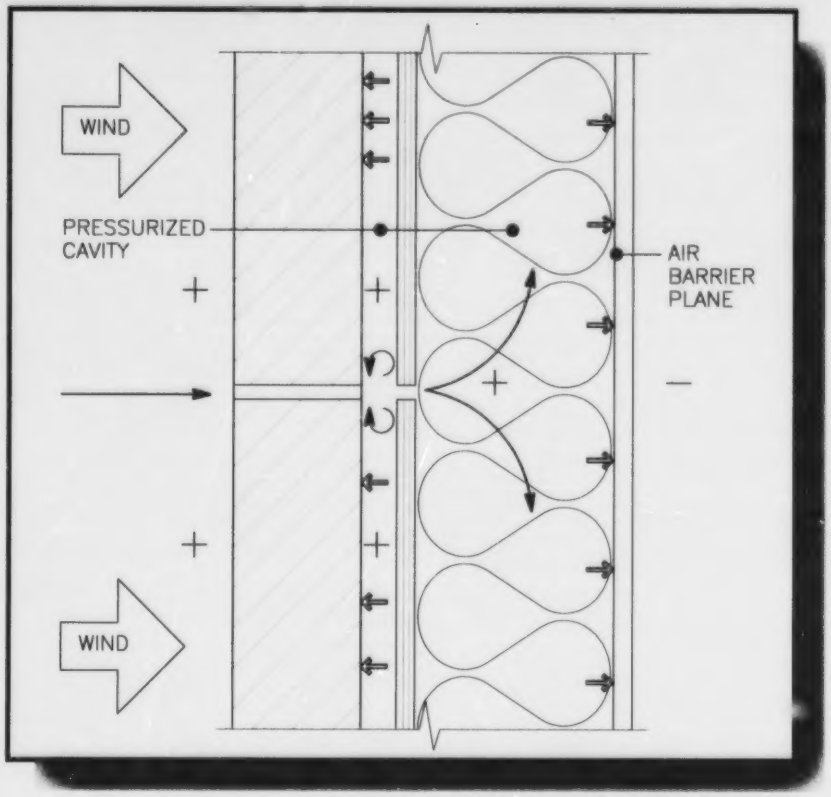


Figure 5.3: Pressure-equalizing rainscreen (Airtight Drywall Approach)

corners, this cavity pressure can be more than twice the actual wind pressure.

The compartments should also be closed at roof level so that air cannot flow into a common roof space.

The Pressure-Equalized Rainscreen system can be applied to most types of cladding systems to some degree. Make sure the following components are present when you apply this system:

- a continuous air-barrier system
- an air space ventilated to the outside
- a moisture barrier such as asphaltic paper or spunbonded olefin on the exterior face of the wall sheathing
- drain holes or gaps for water to leave the cavity, with flashings at wall base, doors and windows, and so on, to direct the water to the outside
- blocking at corners, roof and intermediate points to compartmentalize the cavity

In all cases, the back-up wall must incorporate an effective air-barrier system and a moisture barrier. The following is a discussion of how these components can be applied to common cladding systems.

Masonry Veneer Cladding

The Rainscreen system can be applied to masonry veneer walls very readily because the following components normally form part of the cladding system:

- an air space between the cladding and the back-up wall,
- ventilation and drainage of the cavity to the outside through weepholes and
- flashings at wall openings and at the wall base to direct water to the outside.

To make the system effective, it is also necessary to block the cavity at building corners and at intermediate points.

Vinyl and Aluminum Siding

Most sidings of these types are hollow-backed and naturally create a cavity when applied over sheathing. Preferably, apply them over strapping. The overlapping siding panels discourage the flow of water into the cavity. Any water that does enter can drain out through the integral ventilation and drain holes found in the lower edge of the siding profile. At interior and exterior corners, use corner trims and blocking to create effective compartment seals.

Wood and Wood-Product Siding

Apply siding over strapping to create a cavity, and use corner trim to block the cavity at the corners. Install lapped wood and hardboard siding using round-headed siding nails to maintain a gap between successive boards. This permits ventilation. The base of the wall should be detailed to allow drainage to the exterior (with flashings, where necessary).

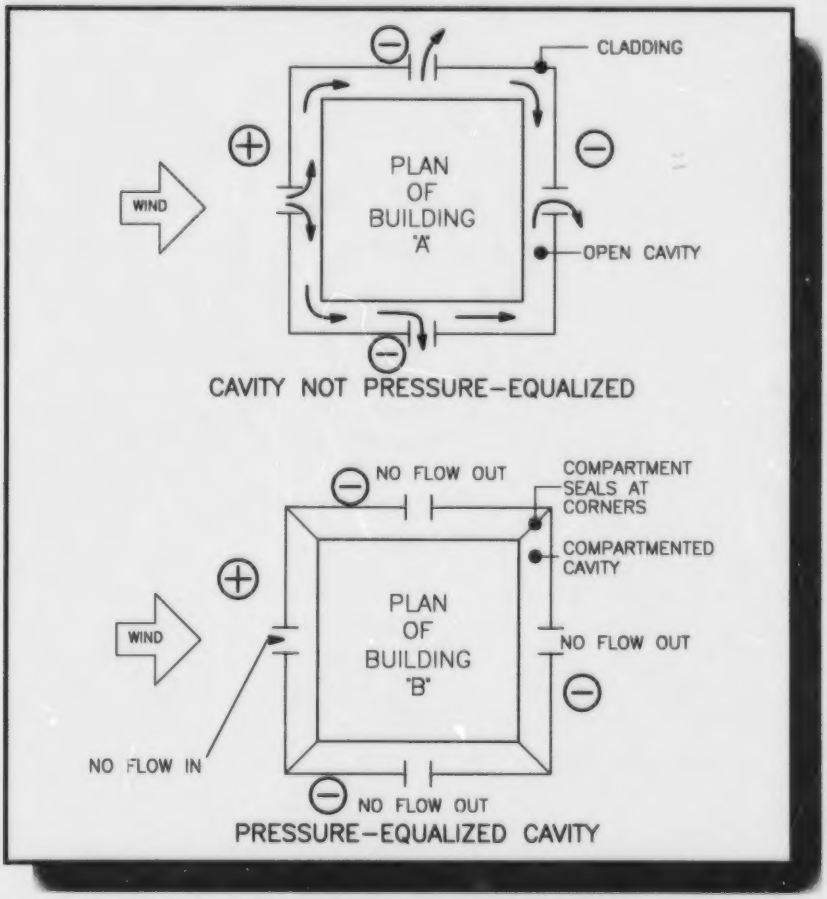


Figure 5.4: How to obtain a

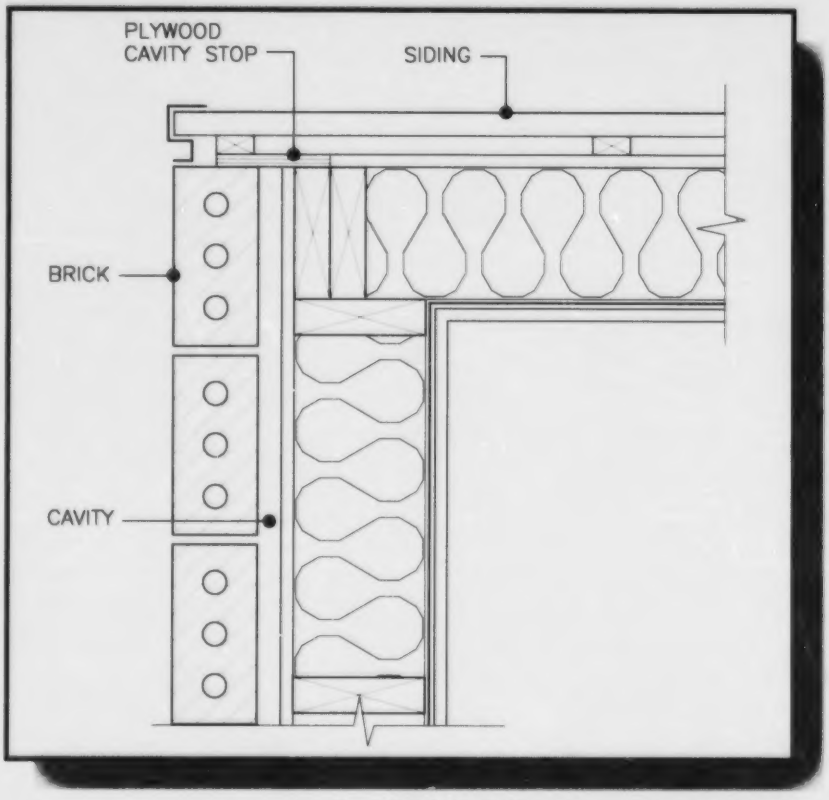


Figure 5.5: Corner compartmentalization between cladding and siding

Cement Stucco

Traditional cement stucco finishes can be designed and constructed as Rainscreens. In the past, most stucco applications were partially vented and drained with the use of self-furring laths. Cement stucco is a three-coat system consisting of a water-tight base coat, a weaker brown coat and a micro-cracked finish coat which also enables the system to perform well.

Some proprietary polymer-based Exterior Insulation Finish Systems (EIFS) have now been designed to provide a ventilated cavity. Refer to specific manufacturers' data for details of installation and the properties of the materials.

Regardless of whether a vented and drained cavity is provided behind the stucco, there will be small voids, gaps and joints in the assembly which permit the passage of air. By minimizing the pressure differential across the stucco component, a pressure-equalized Rainscreen system will substantially reduce the possibility that water will be driven through these gaps into the wall assembly.

DRAINAGE

Design pathways to allow liquid moisture to leave the building envelope. Examples include sloping roofs; eavestroughs leading away from the building; sloping porches and decks; sloped earth at grade to direct surface water away from the building; air spaces left behind cladding such as masonry veneer; and lapped flashing and building paper

(moisture barrier) that intercepts and evacuates the water that passes through most types of cladding.

Flashing and building paper that have gaps or are incorrectly lapped, and moisture traps in decks and porches, lead to many of the problems experienced in envelope performance. Symptoms include dark stains or paint peeling where water has accumulated behind the cladding. Unless complicated joints are properly detailed and flashed, these types of problems become particularly critical, especially for large, multi-storey buildings.

DRYING

Drying allows vapour diffusion, or it allows moisture-laden air to leave the building envelope. Studies have been conducted to determine the drying rates of walls with various commonly available sheathing materials. Here is their ranking:

Fastest	Fibreglass sheathing board and wood fibreboard
Relatively Fast	Plywood and OSB (wood-based panel products)
Less Fast	Extruded polystyrene
Least Fast	Laminated polyisocyanurate

Of these materials, the glass fibre and wood products are hygroscopic, that is, they are porous and are able to wick water away. They have a good capacity for drying. The successful use of foam insulation boards depends on their ability to maintain a warmer temperature in the stud cavity. The water vapour permeance of various sheathing materials is given in Table 5.2. High permeance to water vapour diffusion is desirable in sheathing materials.

It should be noted that the emphasis has been on walls drying to the outside. Walls can also dry to the inside, through construction sequencing, for example, where the interior finish is not applied until later.

DURABILITY

Wood frame structures have withstood the test of time in the Canadian climate, and most of these structures have remained free of decay. With the right combination of materials, design, construction and maintenance, wood buildings can provide any desired service life.

However, if the organic nature of wood is not taken into consideration, such high life expectations will not be met. Wood will remain free from the detrimental effects of decay unless the levels of oxygen, temperature and moisture are too high.

The optimal temperature range for mold and fungal growth is 18°C to 35°C (65°F to 95°F). Above this range, growth decreases and will cease at about 38°C (100°F). Growth also slows as the temperature drops. At cold winter temperatures, the fungi become dormant, but they will be activated again when it gets warmer. When wood is kiln-dried, the decay organisms are killed, but the wood can be quickly reinfected in most environments.

Moisture management is the most effective method of controlling wood deterioration. Decay fungi will germinate and flourish when the moisture content of wood is between 35 and 50 per cent. The spores will not germinate

on wood that has a moisture content below the fibre saturation point (28 per cent MC). However, the fungi may continue to grow at moisture contents down to 20 per cent. At 19 per cent MC and below, wood is considered immune to fungal growth (see Figure 5.6).

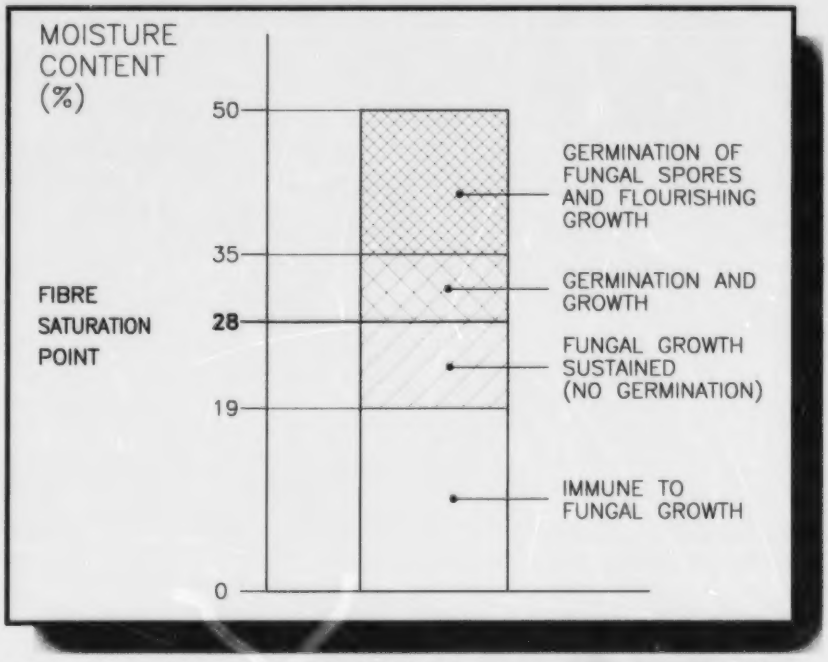


Figure 5.6: Fungal growth in wood

Some species of wood, such as western red cedar, contain naturally occurring chemicals which inhibit the growth of fungi and protect against decay. Lumber may also be pressure-treated to impregnate it with a preservative that prevents the growth of fungi or attack by insects. Due to their cost, these products are generally used only for special applications where prolonged exposure to excessive moisture is expected.

MOISTURE STORAGE AND DISSIPATION

Wood's ability to store moisture is useful for two reasons. First, wood absorbs water that would otherwise accumulate and cause damage to other wall materials. Second, it releases water to the air when moisture is scarce, raising low humidities. Moisture levels in wood should be kept below 19 per cent to prevent deterioration.

Framing lumber will gradually re-release the moisture it has naturally stored, allowing it to migrate through the wall assembly, provided that it can escape. The rate of dissipation depends largely on the air and vapour resistance of materials in the wall system.

In cold winters, moisture transfer from the building interior may result in condensation within the wall cavity during the heating season. In a well-constructed home, the quantity of condensation is not great and is readily dissipated over the course of the year. If the moisture in the wood is not dissipated, fungi may grow when warmer weather returns.

MANAGING LUMBER WITH A HIGH MOISTURE CONTENT

The NBC states that lumber shall have an MC of 19 per cent or less at the time of installation, but this is not always attainable. The lumber may have an

initial moisture content higher than it will have at any other time in service. If kept wet for an extended period, it may start to decay.

Fortunately, a wall assembly is generally able to dry to the exterior. The rate of drying depends partly on the capacity of the sheathing and cladding systems to allow water vapour to diffuse through them, without allowing moisture to enter from outside.

Where dry lumber is not available and the use of framing materials with a high MC is unavoidable, use sheathings which permit fast drying. Foamed plastic insulations, particularly those faced with foil, are less suitable because they must dry to the inside.

The drying process can be further enhanced by creating a ventilation space between the cladding and the sheathing. When masonry veneer is used, a cavity is provided behind the brick. Apply other siding systems over strapping (see Figure 5.7).

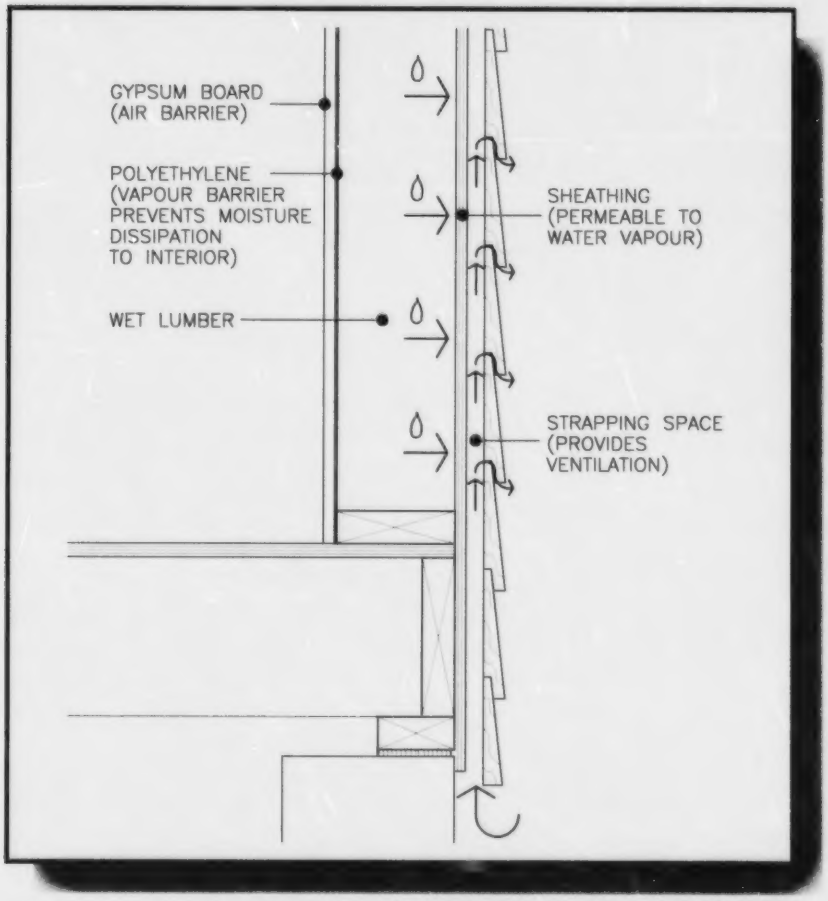


Figure 5.7: Speeding up the dry

Low water-vapour-permeance sheathing materials located at the exterior of a wall assembly can cause problems if there is significant moisture accumulation, even when a wall is constructed of dry wood. The mechanics of this process are discussed in Chapter 4, "Moisture Transfer."

Alternatively, you may schedule the construction sequence to allow walls to dry to the inside, delaying the application of the vapour barrier and interior finish until the walls are dry.

CHAPTER 6

DIMENSIONAL CHANGE

Wood buildings tolerate a wide range of temperature and humidity conditions. The thermal and hygroscopic properties of wood protect occupants and building contents from environmental stress. At the same time, though, changing environmental conditions may cause the dimensions of wood to change.

Dimensional change by itself is not a problem. Difficulties arise when different parts of a structure do not move together, and these difficulties must be addressed. Differential movement occurs with all building materials; for example, brick cladding and concrete block walls expand differently. Wood buildings, however, pose unique challenges because of the integration of wood members with other structural materials.

The ability of wood to change dimensions should be considered in the design of buildings and building envelopes. It is particularly important in multi-storey buildings.

Dimensional change is closely related to fluctuations of moisture content (MC) within the wood.

This chapter examines

- how dimensional change occurs in wood,
- managing dimensional change and
- the compatibility of wood framing with materials that have different characteristics.

HOW DIMENSIONAL CHANGE OCCURS

Expansion and contraction of wood occur relative to the amount of moisture contained in the cell walls of the wood. This dimensional change occurs across the width or thickness, rather than along the length of a piece of wood.

The cell walls are fully saturated at approximately 28 per cent MC. This is called the fibre saturation point. All of wood's shrinkage takes place between the fibre saturation point and the driest condition in service, which may be 6 per cent MC or higher (see Figure 6.1).

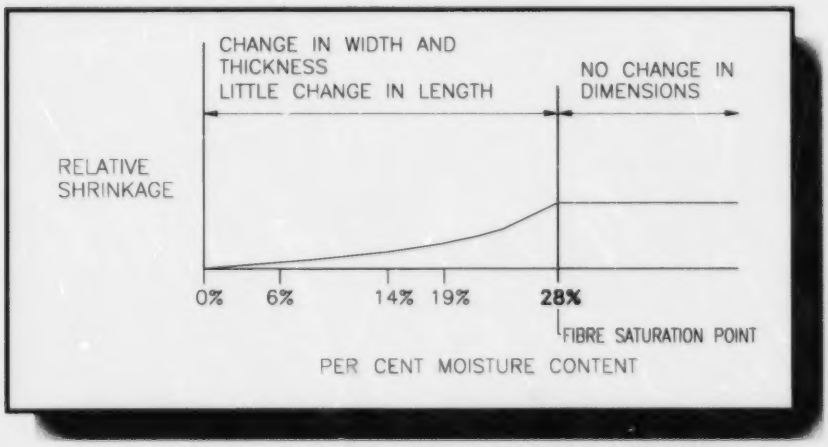


Figure 6.1: Wood shrinkage

It is assumed that no shrinkage will occur along wood's length. The cells expand in width rather than length as their cell walls become saturated. Wood shrinks a bit more around the circumference of a log (the tangential direction) than it does along its radius (the radial direction) (see Figure 2.3). However, this difference is usually ignored, since most wood products contain both radial and tangential sections (see Figure 6.2).

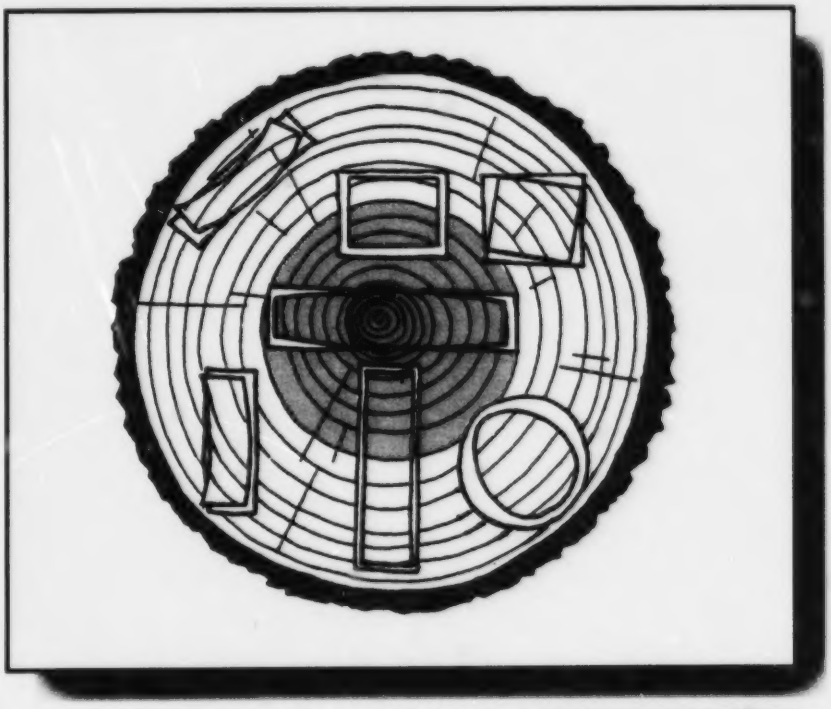


Figure 6.2: Shrinkage changes in wood

Unlike in some other building products, such as plastic or metal, expansion and contraction of wood due to temperature alone is small and can be ignored.

INITIAL MOISTURE CONTENT

The NBC, in Article 9.3.2.5, requires that "moisture content of lumber shall be not more than 19 per cent at the time of installation." S-Grn (surfaced, or dressed, green) and S-Dry (surfaced, or dressed, dry) are the terms used to describe the MC of wood when it is manufactured, not when it is installed. S-Dry means the lumber had a moisture content of 19 per cent or less when it was processed at the mill. S-Grn lumber had an MC above 19 per cent and must be further seasoned prior to use (see Figure 2.3). The physical characteristics of lumber are identified using grade stamps.

S-Dry lumber can be attained by air drying (seasoning) or kiln drying. Kiln drying is the usual process used to achieve S-Dry lumber, and many manufacturers add the designation "Kiln Dried" to their products due to its desirability. In some regions, S-Grn wood arrives at construction sites with an MC in excess of the stipulated 19 per cent and must be dried before installation.

Using dry lumber reduces the likelihood of the following:

- nail popping in drywall,

- twisting of lumber,
- differential movement and
- air leakage through walls due to differential movement.

EQUILIBRIUM MOISTURE CONTENT

The MC of wood products will continue to change after the wood has been installed in a structure. Wood cells will absorb or release moisture from their immediate environment until they reach a state of equilibrium with it. The Equilibrium Moisture Content (EMC) depends on the average air temperature and relative humidity (see Figure 6.3).

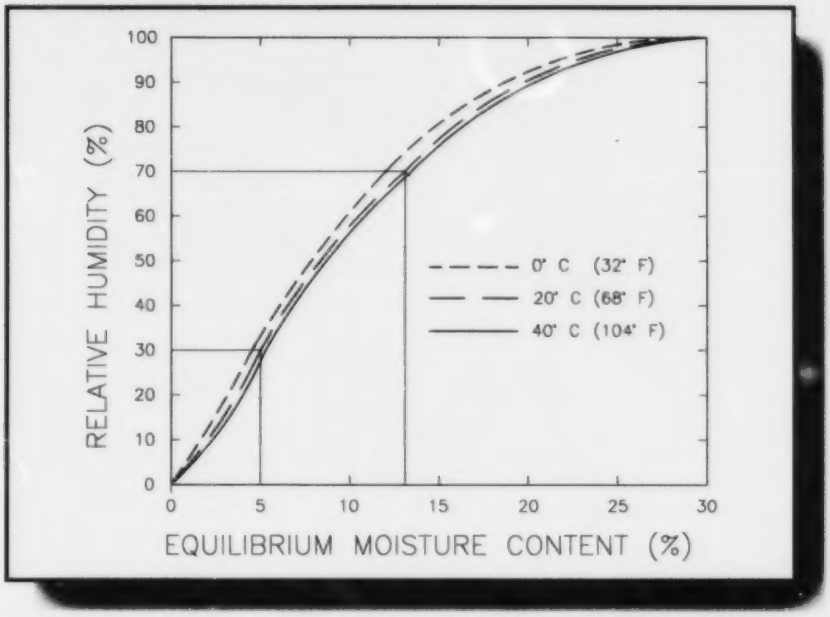


Figure 6.3: Equilibrium moisture content (per cent), relative humidity and temperature

Other factors will affect the moisture content of wood at various locations in the structure:

- natural seasonal variations in temperature and relative humidity
- location of the wood (interior or exterior)
- the building orientation (north, east, south or west)
- shade conditions (heavy shade and shelter vs. an open, sunny location)

Lumber will usually achieve a stabilized moisture content ranging from six per cent to 14 per cent after a drying stage lasting approximately one year, depending on the local climate. See Chapter 5 for further discussion of this drying stage.

Panel products reach a lower EMC than lumber under the same conditions of humidity and temperature. Douglas fir plywood and Canadian softwood plywood are manufactured from rotary-cut veneers cross-laminated under heat and pressure. Oriented strandboard (OSB) is made of aspen strands bonded under heat and pressure. The face layers of the panels are oriented primarily in one direction; this increases their strength in that direction.

The wood veneers and strands used to make these and other engineered wood products (such as laminated veneer lumber) are dried to between three per cent and seven per cent MC prior to fabrication. An increase in wood panels' moisture content may cause dimensional changes. The edges of panels are usually protected with a special paint or sealer to slow absorption, but sheathing panels need to be installed with a 3-mm (1/8-in.) space between them to allow for expansion.

MANAGING DIMENSIONAL CHANGE

Fluctuations in MC through the seasons can lead to dimensional change in wood frame structures. This is normally within the bounds of expected construction tolerances. In extreme conditions, such movement can cause interior finishes and air-barrier systems to crack at the ceiling level.

The most important way to manage dimensional change is to keep wood frame structures dry. This means maintaining air-barrier and vapour-retarding systems, as well as protecting against rain penetration and sources of outside moisture.

If the initial moisture content of wood is too high, minor dimensional problems may result. Following are two specific examples of such problems and their solutions.

CEILING-PARTITION SEPARATION

During the service life of buildings, a crack sometimes develops between the ceiling and interior wall partitions. This is frequently attributed to upward movement of roof trusses known as "truss uplift," but it is often caused by other factors.

Other causes of ceiling-partition separation include foundation settlement, beam sagging, floor shrinkage, floor joist deflection, incompatibility between interior and exterior wall constructions (see "Compatibility with Other Materials" later in this chapter), or construction inaccuracies. It is important that you correctly diagnose the problem before you attempt to correct it.

Floor shrinkage and truss uplift are related to moisture differences. In the case of truss uplift, moisture differences occur between the top and bottom chords of the truss. Differential shrinkage between the top and the drier bottom chord members causes the bottom chord to bow upward (see Figure 6.4). To prevent truss uplift, use dry lumber and keep the attic space dry.

Allowing for movement in the finishes may help eliminate ceiling-partition separation. Try the following:

- Use "floating corners." Fasten the ceiling drywall away from the corner joint and secure it using drywall clips (see Figure 6.5).
- Use moulding to conceal the separation.
- Use connectors with vertical movement slots instead of nailing partitions directly to trusses.

Since ceiling-partition separation occurs within the building envelope, it may not affect the performance of the envelope. However, it can be unsightly, and consumers expect it to be managed.

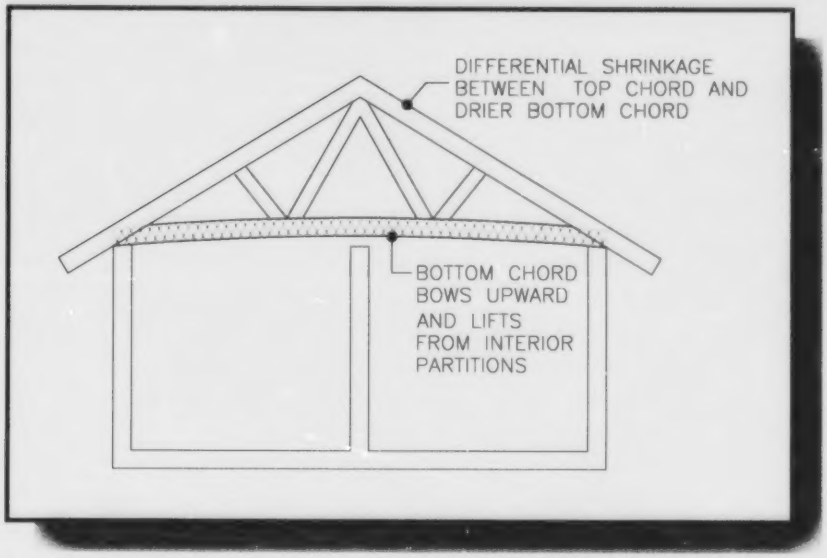


Figure 6.4: Truss uplift

NAIL POPPING

Any shrinkage of wood along the length of an embedded nail may expose part of the nail; the nail head may rise above the surface of the drywall or sheathing it secures. This is unsightly and may lead to a discontinuity in the air barrier system (e.g., where gypsum board is used as the air barrier).

The use of the shortest annular nails or screws necessary to secure the wallboard will reduce the incidence of nail popping. It also helps to use dry lumber for framing.

COMPATIBILITY WITH OTHER MATERIALS

As described in earlier sections of this guide, over time, framing lumber attains an equilibrium moisture content

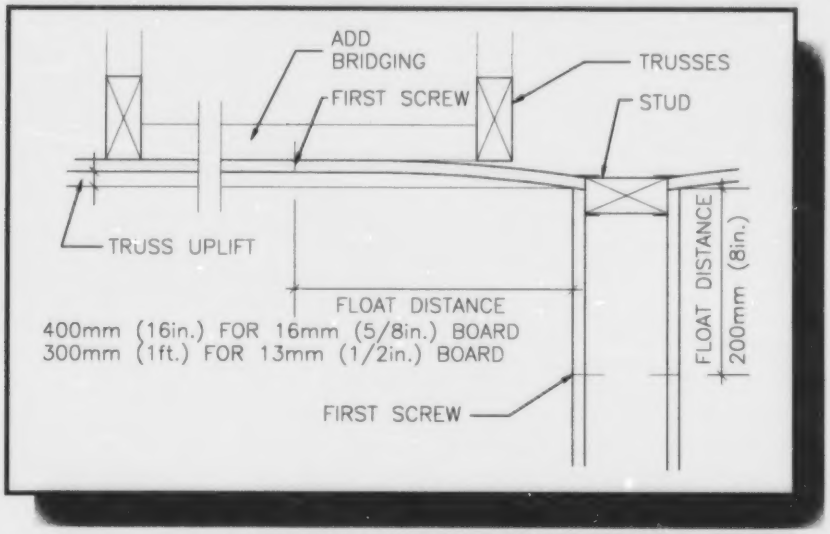


Figure 6.5: "Floating corners"

(EMC) that is typically lower than the MC at the time of construction. It therefore shrinks slightly across its width during an initial period of one year. Plywood and other panel products generally have a low MC at the time of manufacture, so the reverse usually happens. Due to the flexibility of wood structures, lumber and panels perform well when used together, provided the panel products are not constrained from expanding.

Differential movement should be considered when wood is used in combination with other materials such as steel, glass blocks or masonry and with glued-laminated timber or laminated veneer lumber.

Shrinkage is expected in lumber across its width, while longitudinal shrinkage is negligible. In a structure of several storeys, each of the wall plates and joists will contribute to a significant overall shrinkage. Actual shrinkage varies between various wood species. However, a typical assumption of one per cent shrinkage per four per cent MC change is used by most designers.

In a three-storey structure frame with 235-mm (nominal 10-in.) spruce joists installed at 19 per cent MC, the overall shrinkage of joists and plates will be 14 to 20 mm (9/16 in. to 3/4 in.) when an MC of 10 per cent is reached.

Portions of the structure supported on masonry or steel will remain at a constant elevation relative to the portions supported solely on wood-bearing

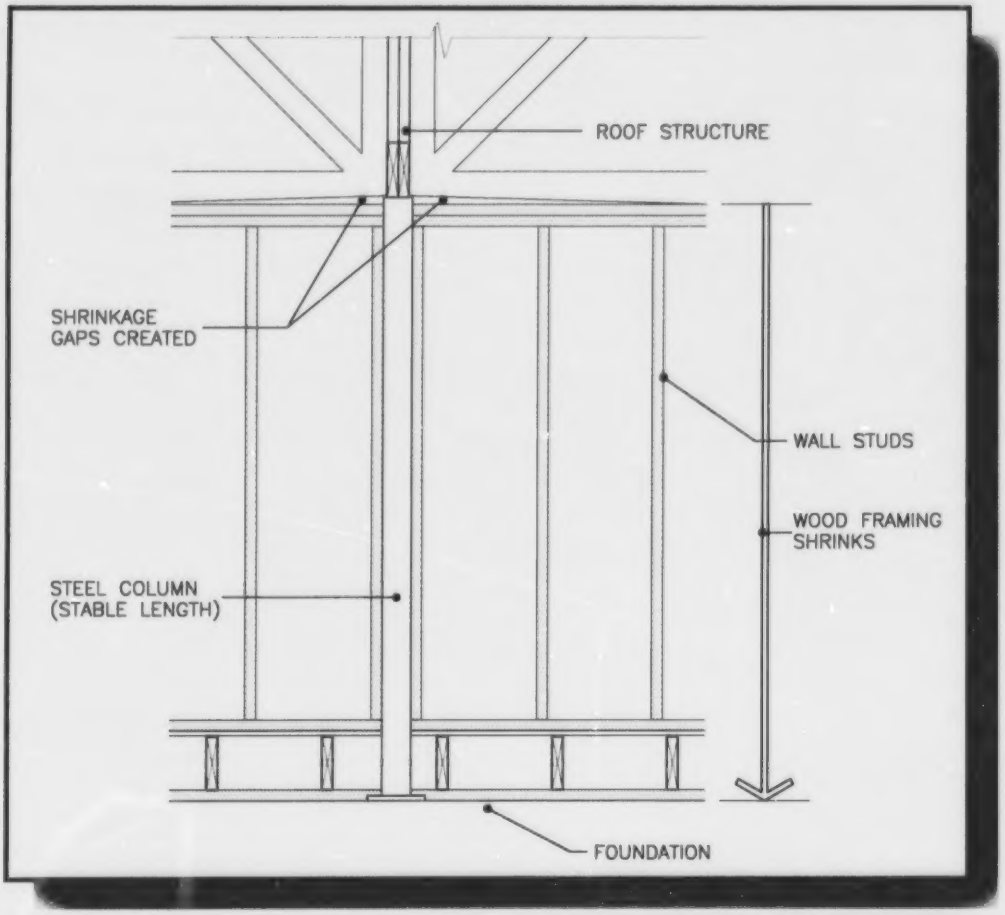


Figure 6.6: Steel column within wood f

walls. (Note: The critical factor is the total sum of the dimensions of horizontal, not vertical, wood members. It is important that the sum of horizontal wood supporting different parts of the structure be uniform throughout.)

Here are some examples of problems which might result from shrinkage:

Example 1

A steel column is built into an exterior wall to carry the load of a beam. The wall shrinks and the column doesn't. Gaps open up in the wall's joints (see Figure 6.6).

Recommendation

Determine the sum of the horizontal wood members in the wall. Use the same vertical dimension of horizontal wood to support the beam.

Example 2

Row houses are built with concrete block party walls. The exterior wood frame walls are installed with a 19 per cent MC. Over a year, they reach an MC of 10 per cent, resulting in a cumulative shrinkage of 14 mm (9/16 in.) in

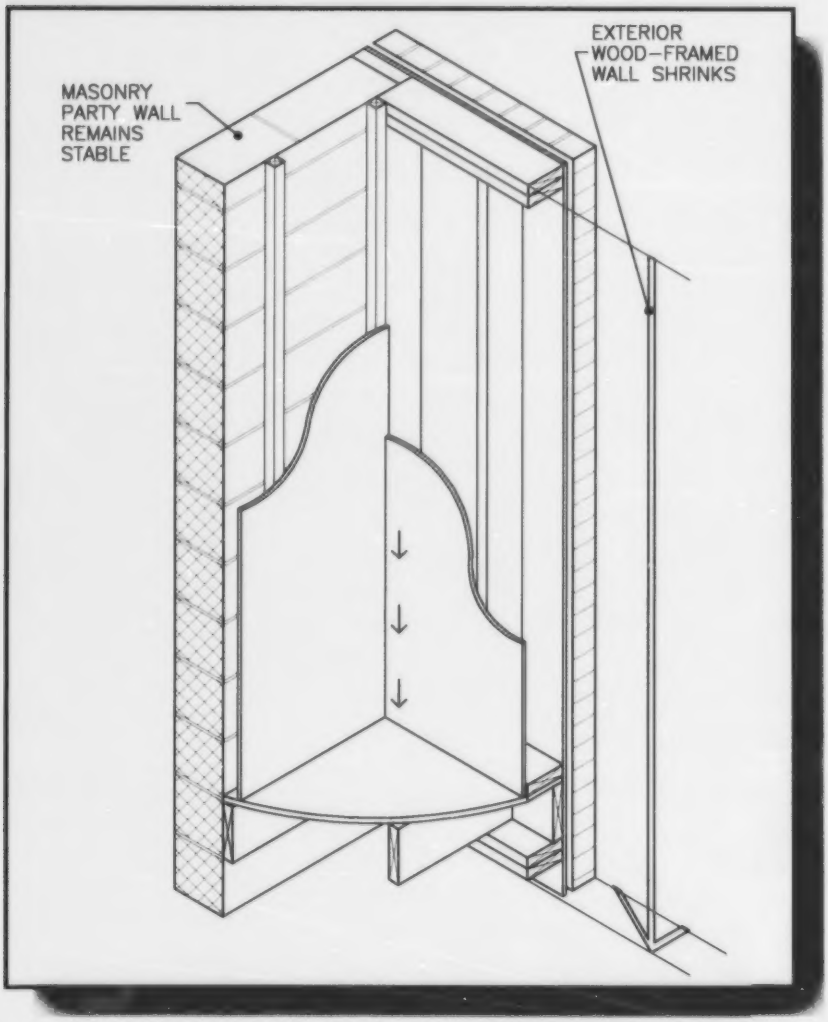


Figure 6.7: Separation of masonry party wall and wood-framed wall

the horizontal members (plates and joists). The drywall finish at the junction of the party wall and exterior wall separates (see Figure 6.7).

Recommendations

Support the gypsum wallboard at the party wall on framing that is independent of the masonry, using the same cumulative width of horizontal wood members, or provide a movement joint at the junction of the two assemblies.

Example 3

The balconies in a four-storey apartment building are supported on steel columns. The wood structure shrinks 20 mm (3/4 in.) upon drying, while the

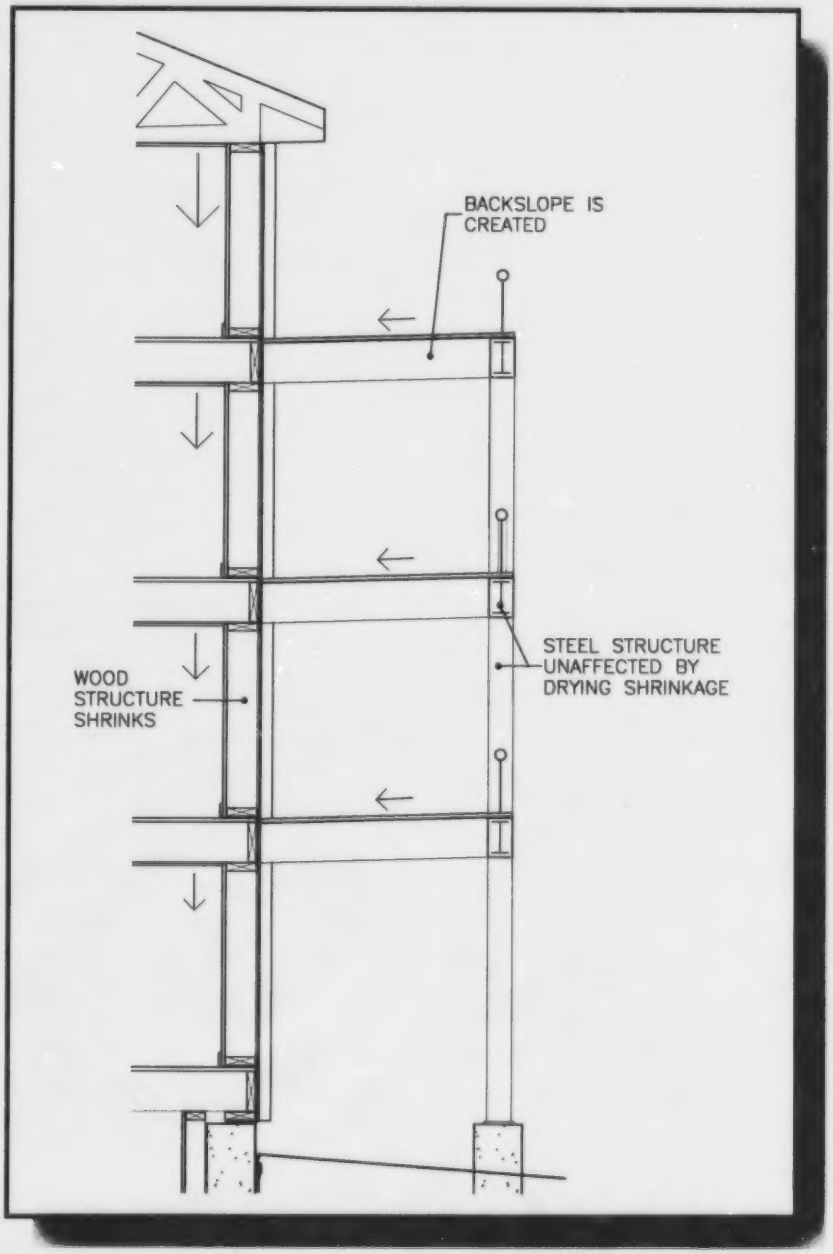


Figure 6.8: Balconies on st

steel columns do not shrink. The balconies develop a back slope which allows water to run back into the building envelope (see Figure 6.8).

Recommendations

1. Support the balconies on a wood structure which exhibits the same shrinkage as the wall structure, or construct the balconies as an independent structure.
2. Provide a cant strip with a sufficient slope to ensure positive drainage once shrinkage has occurred.
3. Design the length of steel columns so that after shrinkage has occurred, positive drainage away from the building envelope will be provided.

Example 4

A four-storey wood frame apartment building is clad on the lower three floors with brick veneer. A cap flashing covers the top of the brick. The wood structure shrinks 20 mm (3/4 in.) and distorts the brick cap flashing, allowing water to flow into the wall.

Recommendation

Provide a flashing profile which allows movement between the brick veneer and the wood frame without distorting the flashing (see Figure 6.9).

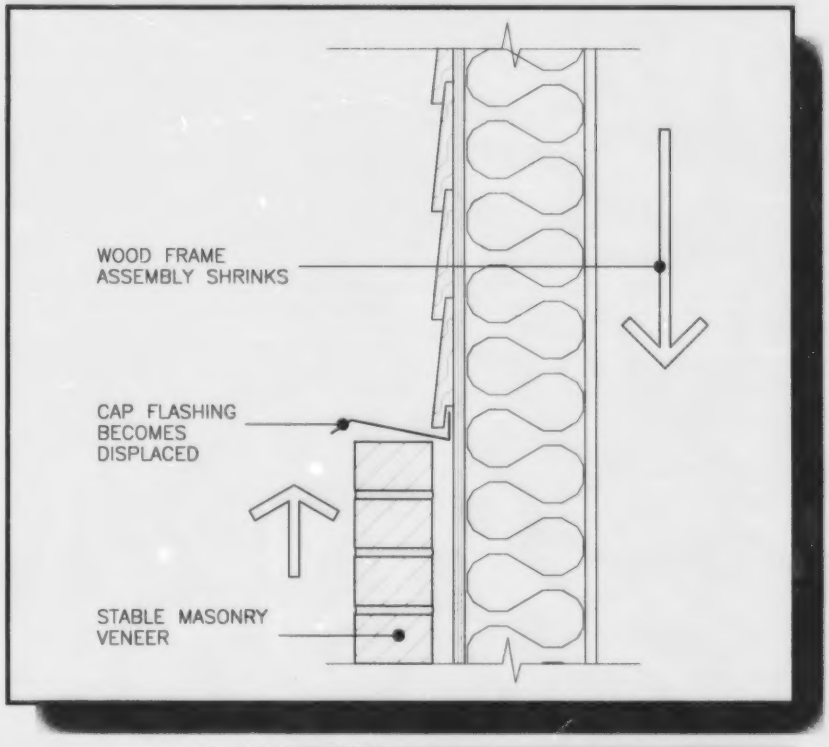


Figure 6.9: Wood frame

CHAPTER 7

DETAILS

This chapter presents details for three types of wall assemblies. These details represent best practices in wood frame building envelope wall construction. They show how you can apply the concepts and the design criteria discussed in the previous chapters. These details are intended to be examples, and you may substitute other materials as long as they do not violate the principles of envelope performance. If dry lumber is not available, for example, be sure to select an exterior sheathing with a high water-vapour permeability, or delay enclosing the wall until it has dried out. Base your decisions on calculations such as those found in CMHC's EMPTIED computer program.

Consider the following elements when you select a wall system:

- type of cladding
- air-barrier system
- degree of thermal resistance
- types of insulation
- type of vapour-diffusion retarder
- interior finish material

Table 7-1 summarizes the principal features of the three wall systems depicted.

The air-barrier systems illustrated in this chapter can all be used with various types of cladding.

Where appropriate, the special details for elements such as foundations, window openings, floor cantilevers, balconies, wheelchair accessibility and party walls that are presented in this chapter apply to the three sample wall systems.

Wall System C (External Airtight Sheathing Element [EASE]) is illustrated with a flat roof. Flat or sloped roof systems may be used with all the wall systems.

Table 7.1: Characteristics of Sample Wall Assemblies

	Assembly A	Assembly B	Assembly C
Wall System	Non-insulation sheathing	Exterior insulation system	EASE system
Air-Barrier System	Polyethylene	ADA	EASE
Air Permeability of Principal Air-Barrier Element (L/s-m^2 @ 75 Pa [gal./s.-ft.^{2} @ 0.01 lb./in.^{2}])	0.0 Polyethylene	0.02 (0.00041)	0.09 (0.00184) (sheathing system)
Vapour-Diffusion Retarder	Polyethylene 0.15 mm (6 mil)	Vapour-barrier paint on gypsum board	Polyethylene 0.05 mm (2 mil)
Water-Vapour Permeability (ng/Pa/s/m^2 [grain/ft.^{2}/hr. (in. Hg)])	9.10 (0.16)	26.00 (0.45)	9.10 (0.16)
Exterior Wall Sheathing	OSB or plywood	Fibreglass insulation board with spunbonded polyolefin membrane facer	Spunbonded polyolefin sandwiched between 2 layers of fibreboard
Water-Vapour Permeability (ng/Pa/s/m^2 [grain/ft.^{2}/hr. (in. Hg)])	40-200 (0.70-3.48)	1 700 (29.56)	200-1 000 (3.48-17.39)
Thermal Performance RSI using 38 x 140-mm studs @ 400 mm on centre (o.c.) (nominal 2 x 6-in. studs @ 16 in. o.c.)	RSI 3.0 to 3.25 (R-17 to R-18.5) Assembly A includes batt insulation in the stud space.	RSI 3.0 to 3.25 (R-17 to R-18.5) Assembly A includes batt insulation in the stud space.	RSI 3.15 (R-18) Assembly C includes batt insulation in the stud space.
Illustrated Cladding	Brickwork	Siding	Cement stucco

WALL ASSEMBLY A

BASIC STUD WALL WITH POLYETHYLENE AIR BARRIER AND VAPOUR RETARDER–DETAILS 1, 2, 3, 4 AND 5

The wall assembly consists of simple stud walls with plywood or OSB sheathing and brick veneer. Batt or blown insulation may be used between the studs.

Air Barrier

Polyethylene measuring 0.15 mm (6 mil.) placed continuously on the interior surface of the studs constitutes the air barrier (AB). Continuity of the AB at floor levels is provided by a supported spunbonded polyolefin. The effectiveness of the membrane as an air barrier is achieved by sandwiching it between framing and sheathing. The junction between the polyethylene and the spunbonded polyolefin is made with sealant.

Penetrations of the polyethylene for electrical outlets and lights must be sealed by special electrical boxes with integral air barrier gaskets. At all connections, such as where partitions abut exterior walls, the polyethylene air barrier must be installed continuously with other air barrier elements (see Detail 5). Wiring penetrations of the exterior wall must be caulked.

Where building elements such as bathtubs or stairs are installed directly against exterior wall studs, special details must be used to ensure that the air-barrier element is continuous behind them (see Detail 2).

Vapour Retarder

The vapour retarder (which also functions as the air barrier in this wall system) consists of 0.15-mm (6-mil.) polyethylene in the walls and is installed on the warm side of the insulation. Between joists, insulation-filled polyethylene pillows are friction-fit.

Notes

- This is the most commonly used system in wood frame construction. An effective air barrier and vapour retarder are provided in a single step.
- The thermal performance of the wall is reduced by thermal bridging through the studs.
- The NBC permits the use of building paper, polyethylene or asphalt-impregnated building paper as dampproofing below grade.

Designer's Checklist

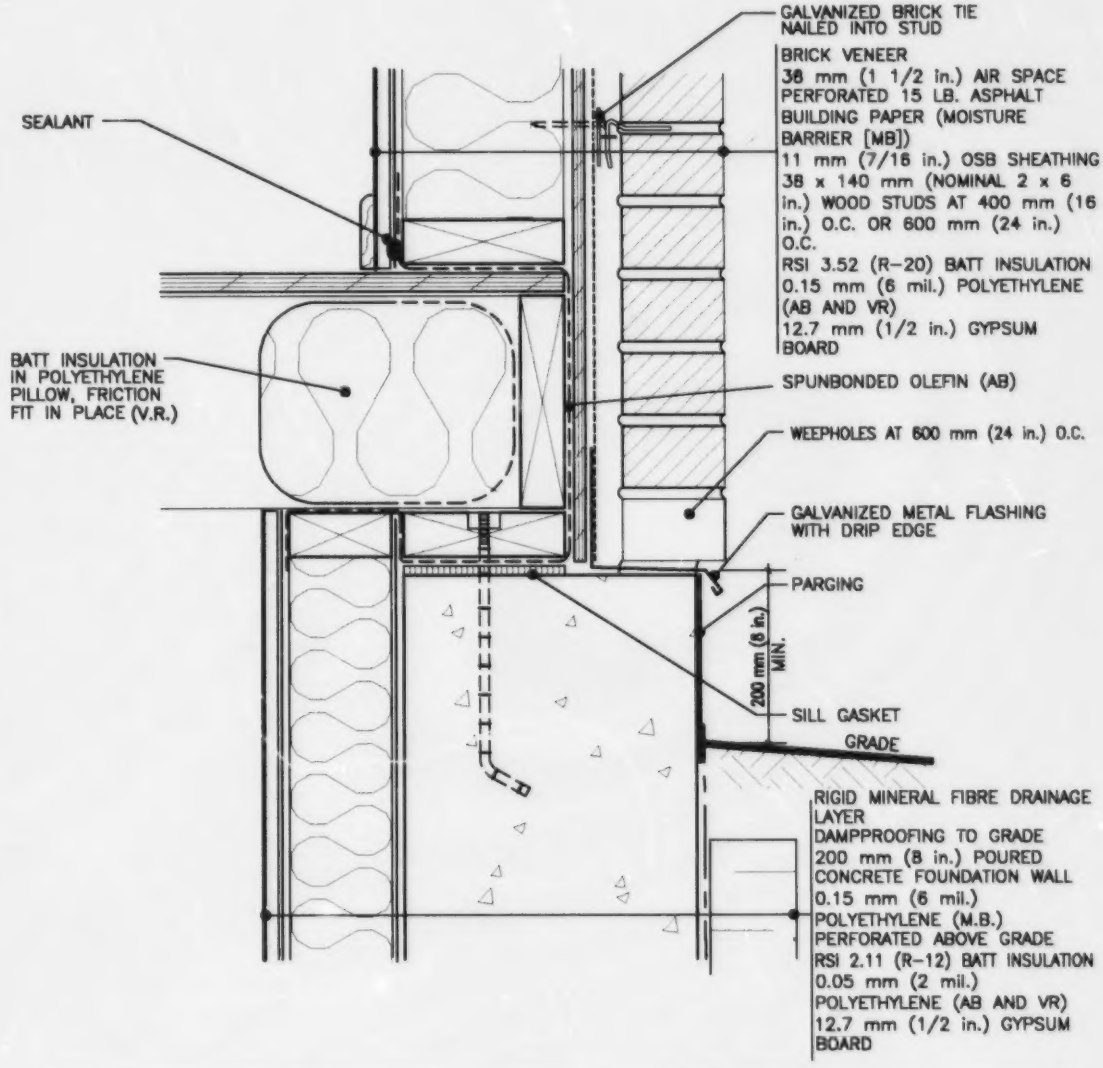
- Specify acoustical sealant for use on interior air barrier components. (Monomeric sealants give off unpleasant solvent gases.)
- Ensure that the junction of the exterior walls with party walls, fire walls, penetrations or any other interruption is correctly detailed to achieve air-barrier continuity. (See subsequent sections for special condition details.)
- The polyethylene is sandwiched between the two top plates of the wall. This is done to avoid having a slippery platform on which to erect the roof structure and also to protect the polyethylene air barrier from being damaged during roof construction.
- Use raised heel trusses to ensure that adequate insulation and ventilation space is provided at roof eaves.

- As an option, 15.6-mm (5/8-in.) gypsum board may be nailed directly to the roof members instead of the detail shown (furring strips and 12.7-mm [1/2-in.] gypsum board under the roof members). The furring strips help to provide a regular nailing base and a space inside the air barrier for passing electrical wiring.
- Rainscreen wall systems must be blocked at building corners to prevent wind suctioning of the cavity from adjacent sides (see Detail 4).

Builder's Checklist

Construction sequencing will determine the placement of the soffit panels, either above the brick as is shown in the detail, or abutting it.

- Leave a gap between adjacent sheathing panels to allow for expansion.
- Lap and seal joints in flashings.
- Coordinate the installation of the air barrier with framers.
- Maximum brick overhang is one third the thickness of brick.
- Keep weepholes completely clear.
- Ensure that the sealant beads at air barrier junctions are continuous, sufficiently large and well installed.
- Ensure that gasket-type electrical boxes are properly installed.
- Ensure that the insulation fills the cavity completely and is carefully fitted around obstructions.


GALVANIZED BRICK TIE NAILED INTO STUD
BRICK VENEER
38 mm (1 1/2 in.) AIR SPACE
PERFORATED 15 LB. ASPHALT BUILDING PAPER (MOISTURE BARRIER [MB])
11 mm (7/16 in.) OSB SHEATHING
38 x 140 mm (NOMINAL 2 x 6 in.) WOOD STUDS AT 400 mm (16 in.) O.C. OR 600 mm (24 in.) O.C.
RSI 3.52 (R–20) BATT INSULATION
0.15 mm (6 mil.) POLYETHYLENE (AB AND VR)
12.7 mm (1/2 in.) GYPSUM BOARD
SEALANT
BATT INSULATION IN POLYETHYLENE PILLOW, FRICTION FIT IN PLACE (V.R.)
SPUNBONDED OLEFIN (AB)
WEEPHOLES AT 600 mm (24 in.) O.C.
GALVANIZED METAL FLASHING WITH DRIP EDGE
PARGING
200 mm (8 in.) MIN.
SILL GASKET
GRADE
RIGID MINERAL FIBRE DRAINAGE LAYER
DAMPPROOFING TO GRADE
200 mm (8 in.) POURED CONCRETE FOUNDATION WALL
0.15 mm (6 mil.) POLYETHYLENE (M.B.)
PERFORATED ABOVE GRADE
RSI 2.11 (R–12) BATT INSULATION
0.05 mm (2 mil.) POLYETHYLENE (AB AND VR)
12.7 mm (1/2 in.) GYPSUM BOARD

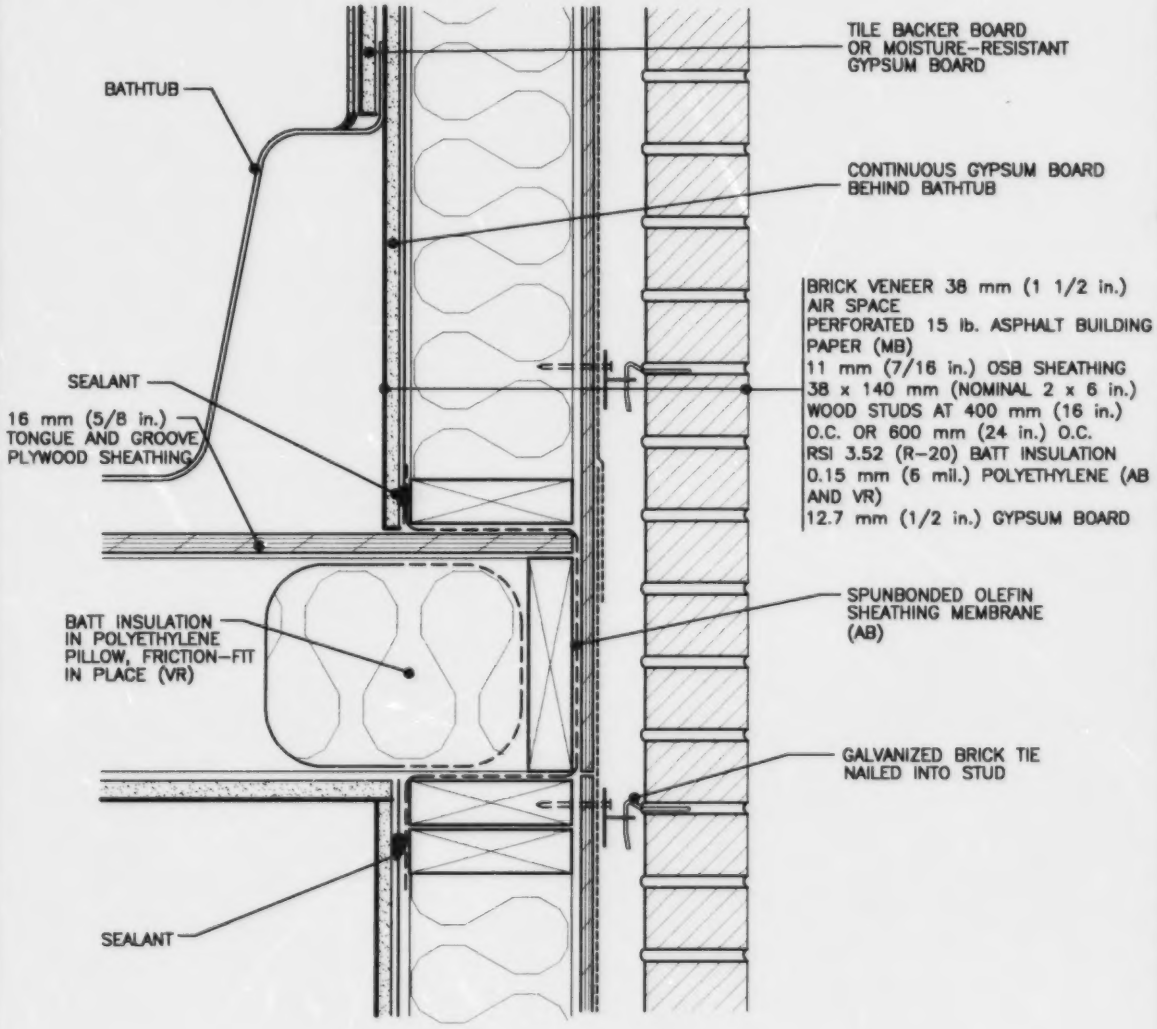
BRICK VENEER WALL AT FOUNDATION

SCALE: 1:5

BASIC POLYETHYLENE STUD WALL (WALL ASSEMBLY A)

1

Detail 1: Brick Veneer Wall at Foundation



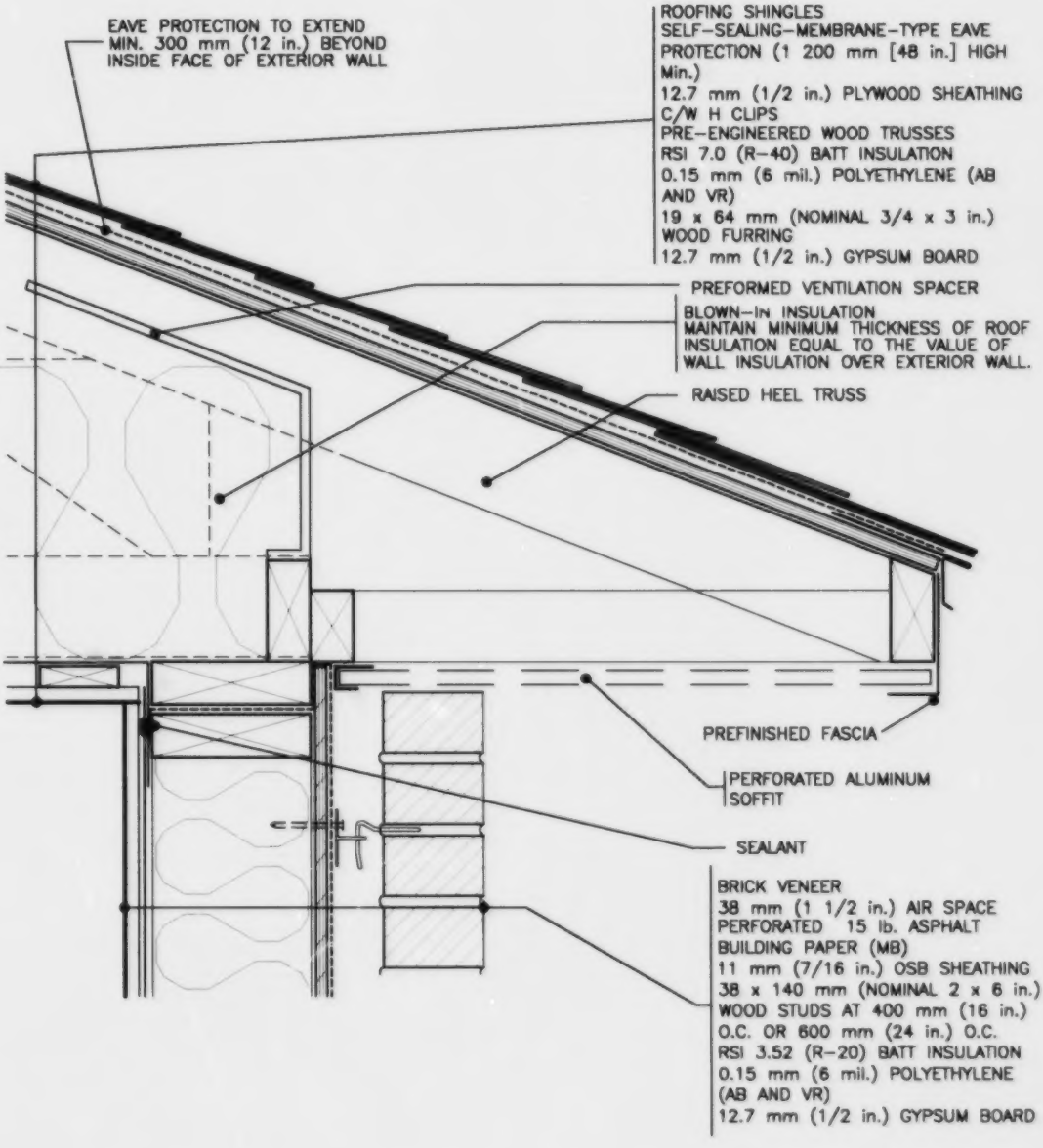
BRICK VENEER WALL AT HEADER

SCALE: 1:5

BASIC POLYETHYLENE STUD WALL (WALL ASSEMBLY A)

2

Detail 2: Brick Veneer Wall at Header


EAVE PROTECTION TO EXTEND MIN. 300 mm (12 in.) BEYOND INSIDE FACE OF EXTERIOR WALL
ROOFING SHINGLES
SELF–SEALING–MEMBRANE–TYPE EAVE PROTECTION (1 200 mm [48 in.] HIGH Min.)
12.7 mm (1/2 in.) PLYWOOD SHEATHING C/W H CLIPS
PRE–ENGINEERED WOOD TRUSSES
RSI 7.0 (R–40) BATT INSULATION
0.15 mm (6 mil.) POLYETHYLENE (AB AND VR)
19 x 64 mm (NOMINAL 3/4 x 3 in.) WOOD FURRING
12.7 mm (1/2 in.) GYPSUM BOARD
PREFORMED VENTILATION SPACER
BLOWN–IN INSULATION
MAINTAIN MINIMUM THICKNESS OF ROOF INSULATION EQUAL TO THE VALUE OF WALL INSULATION OVER EXTERIOR WALL.
RAISED HEEL TRUSS
PREFINISHED FASCIA
PERFORATED ALUMINUM SOFFIT
SEALANT
BRICK VENEER
38 mm (1 1/2 in.) AIR SPACE
PERFORATED 15 lb. ASPHALT BUILDING PAPER (MB)
11 mm (7/16 in.) OSB SHEATHING
38 x 140 mm (NOMINAL 2 x 6 in.) WOOD STUDS AT 400 mm (16 in.) O.C. OR 600 mm (24 in.) O.C.
RSI 3.52 (R–20) BATT INSULATION
0.15 mm (6 mil.) POLYETHYLENE (AB AND VR)
12.7 mm (1/2 in.) GYPSUM BOARD

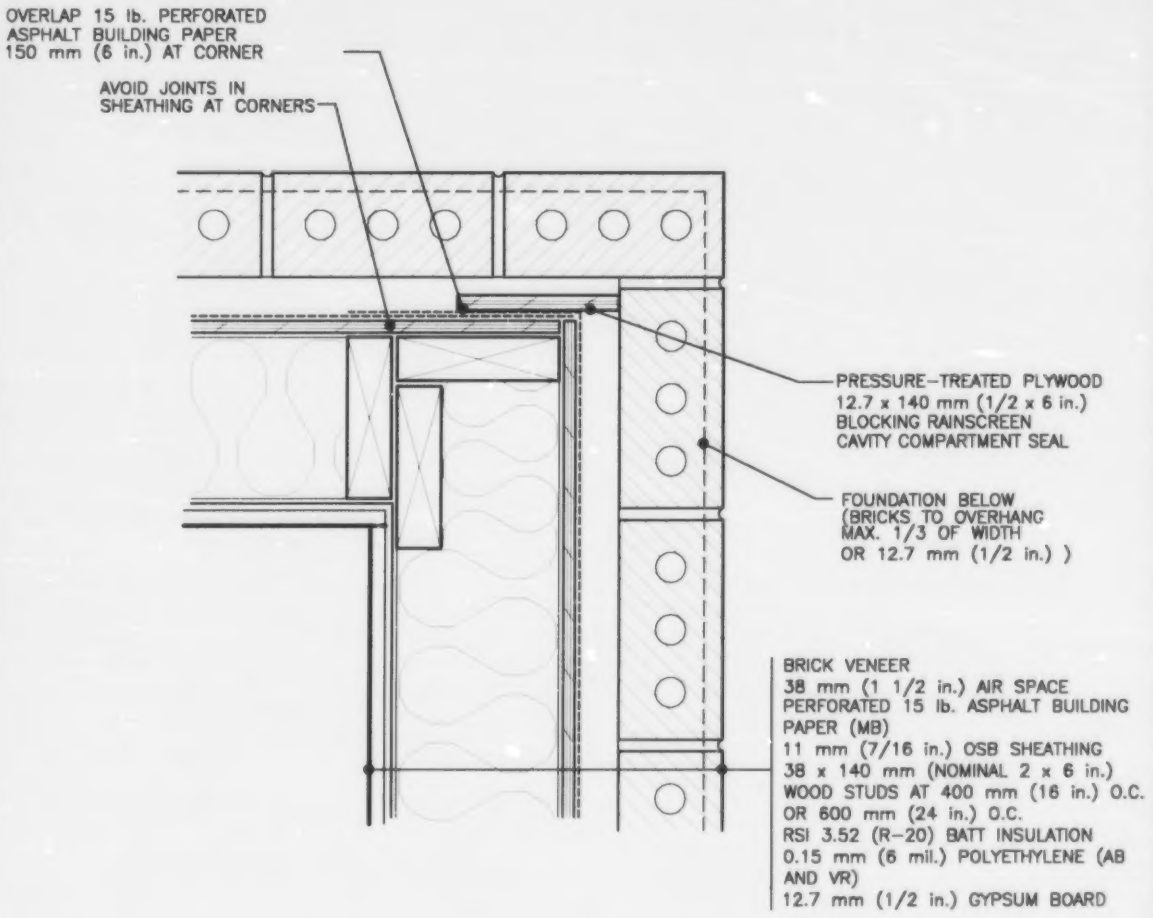
BRICK VENEER WALL AT ROOF

SCALE: 1:5

BASIC POLYETHYLENE STUD WALL (WALL ASSEMBLY A)

3

Detail 3: Brick Veneer Wall at Roof


OVERLAP 15 lb. PERFORATED ASPHALT BUILDING PAPER 150 mm (6 in.) AT CORNER
AVOID JOINTS IN SHEATHING AT CORNERS
PRESSURE-TREATED PLYWOOD 12.7 x 140 mm (1/2 x 6 in.) BLOCKING RAINSCREEN CAVITY COMPARTMENT SEAL
FOUNDATION BELOW (BRICKS TO OVERHANG MAX. 1/3 OF WIDTH OR 12.7 mm (1/2 in.))
BRICK VENEER
38 mm (1 1/2 in.) AIR SPACE
PERFORATED 15 lb. ASPHALT BUILDING PAPER (MB)
11 mm (7/16 in.) OSB SHEATHING
38 x 140 mm (NOMINAL 2 x 6 in.) WOOD STUDS AT 400 mm (16 in.) O.C. OR 600 mm (24 in.) O.C.
RSI 3.52 (R-20) BATT INSULATION
0.15 mm (6 mil.) POLYETHYLENE (AB AND VR)
12.7 mm (1/2 in.) GYPSUM BOARD

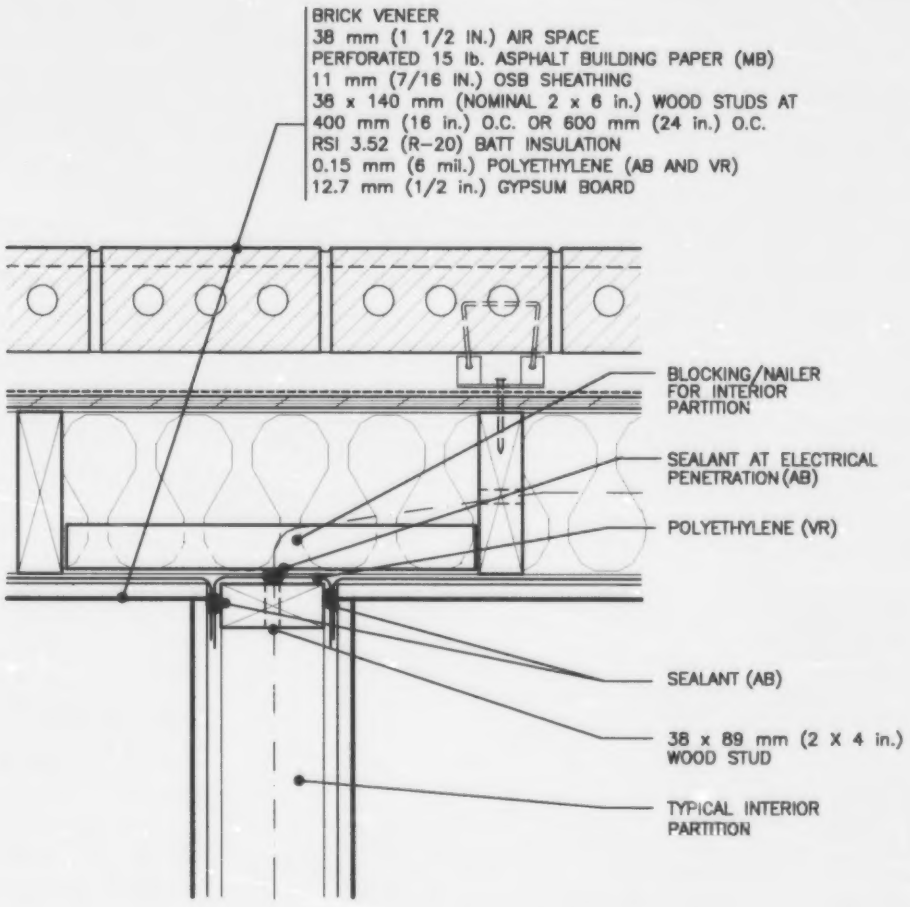
CORNER, HORIZONTAL SECTION

SCALE: 1:5

BASIC POLYETHYLENE STUD WALL (WALL ASSEMBLY A)

4

Detail 4: Corner, Horizontal Section


BRICK VENEER
38 mm (1 1/2 IN.) AIR SPACE
PERFORATED 15 lb. ASPHALT BUILDING PAPER (MB)
11 mm (7/16 IN.) OSB SHEATHING
38 x 140 mm (NOMINAL 2 x 6 in.) WOOD STUDS AT
400 mm (16 in.) O.C. OR 600 mm (24 in.) O.C.
RSI 3.52 (R-20) BATT INSULATION
0.15 mm (6 mil.) POLYETHYLENE (AB AND VR)
12.7 mm (1/2 in.) GYPSUM BOARD
BLOCKING/NAILER FOR INTERIOR PARTITION
SEALANT AT ELECTRICAL PENETRATION (AB)
POLYETHYLENE (VR)
SEALANT (AB)
38 x 89 mm (2 X 4 in.) WOOD STUD
TYPICAL INTERIOR PARTITION

INTERIOR PARTITION, HORIZONTAL SECTION

SCALE: 1:5 **BASIC POLYETHYLENE STUD WALL (WALL ASSEMBLY A)** (5)

Detail 5: Interior Partition, Horizontal Section

WALL ASSEMBLY B

EXTERIOR INSULATION SYSTEM WITH AIRTIGHT DRYWALL APPROACH (ADA)–DETAILS 6, 7, 8, 9 AND 10

The wall assembly B consists of simple stud walls with an exterior glass fibre 38-mm (nominal 2-in.)-thick insulation. The walls must be diagonally braced.

Spunbonded polyolefin laminated to the face of the insulation provides the needed moisture barrier. The sheathing joints are taped.

The wall cladding is applied over strapping and creates a Rainscreen cavity.

Compared to Wall System A, the thermal performance of the wall assembly is improved by a reduction in thermal bridging at the framing members and an increase in insulation levels.

Air Barrier

The interior gypsum board constitutes the air barrier on the framed walls.

Continuity of the air barrier at floor level is provided by gasketing.

(The spunbonded polyolefin-faced fibreglass sheathing has an expected air leakage rate in excess of 0.15 L/s-m^2 @ 75 Pa [0.003 gal./s.-ft.^{2} @ 0.01 lb./in.^{2}]) and is not considered the air barrier element.)

Penetrations of the gypsum board for electrical outlets and lights must utilize special electrical boxes with integral air-barrier gaskets. Where partitions abut exterior walls, the gypsum board must be gasketed along the height of the adjacent partition stud. Wiring penetrations of the exterior wall must be caulked.

Where building elements such as bathtubs or stairs might be installed directly against exterior wall studs, special details must be used to ensure that the air-barrier elements are continuous behind them.

Vapour Retarder

The vapour retarder consists of vapour retarder paint. Between joists an insulation-filled, polyethylene pillow is friction-fit.

The vapour retarder paint is a Type II vapour retarder and is suitable in this assembly because the exterior sheathing is highly moisture permeable. (Other vapour retarders such as foil-backed gypsum board may be used in place of vapour barrier paints as long as they do not interfere with the air-barrier gasketing system.)

Advantages

Greater thermal performance than Wall Assembly A provides is achieved through the use of exterior insulation. Thermal bridging through the studs is reduced.

The glass fibre sheathing system is highly permeable to water vapour and promotes drying of the wall assembly.

Disadvantages

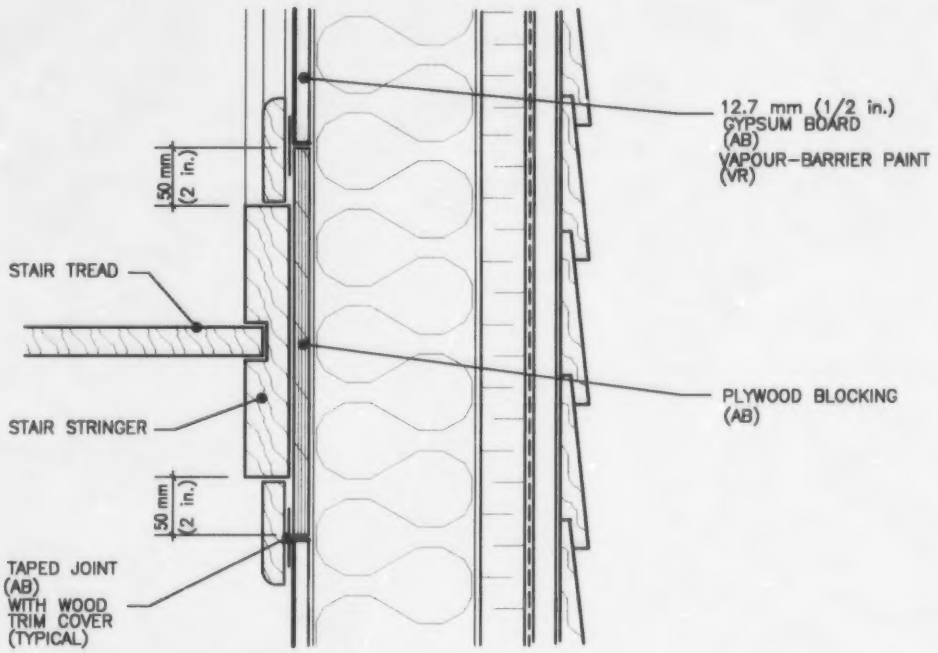
Air barrier gaskets need to be installed during framing.

Designer's Checklist

- Ensure that the junction of the exterior walls with party walls, firewalls or any other interruption is correctly detailed to achieve air-barrier continuity. (See subsequent sections for special condition details.)
- Rainscreen wall systems require blocking at building corners to prevent wind suctioning of the cavity from adjacent sides (see Detail 10).
- Use raised heel trusses to ensure that adequate insulation and ventilation space is provided at roof eaves.
- As an option, 15.9-mm (5/8-in.) gypsum board may be nailed directly to the roof members instead of the ceiling detail shown (furring strips and 12.7-mm [1/2-in.] gypsum board under the roof members). However, the furring strips help to provide a regular nailing base and a space inside the air barrier for passing electrical wiring.
- Specify closed-cell polyvinylchloride (PVC) or cellular foam Ethylene Propylene Diene Monomer (EPDM) gaskets for the drywall.
- Specify back-painted wood cladding materials.

Builder's Checklist

- Co-ordinate the installation of gaskets with drywall installation.
- Ensure that drywall compresses the gaskets to achieve an effective seal.
- Ensure that gasket-type electrical boxes are properly installed.
- Seal sheathing joints with tape. Strapping and nailing through sheathing requires particular care to prevent deformation.
- Seal the back of wood cladding with paint to increase the longevity of exterior paint finishes.



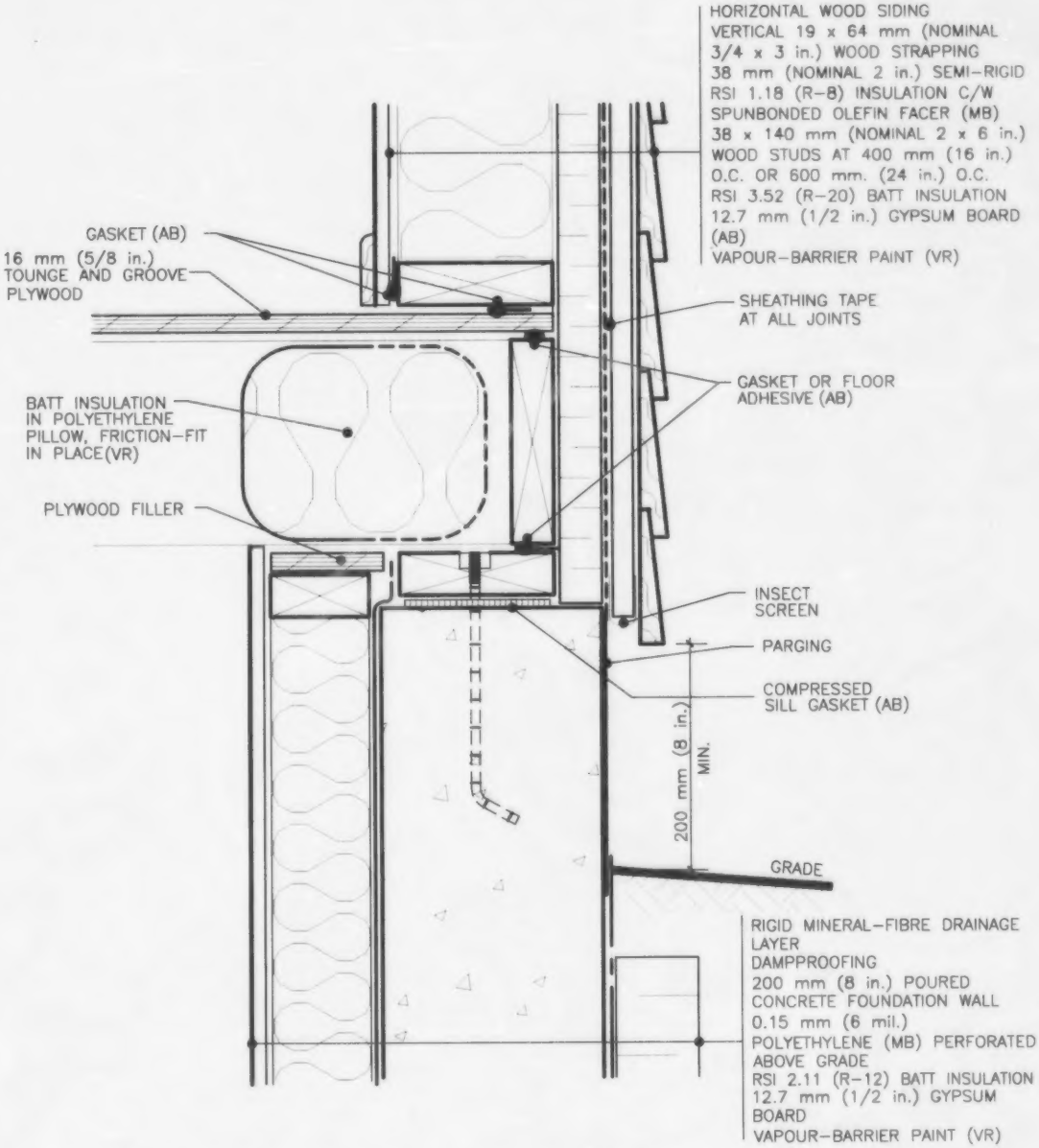
SECTION AT STAIR STRINGER

SCALE: 1:5

EXTERIOR ADA INSULATION SYSTEM (WALL ASSEMBLY B)

6

Detail 6: Section at Stair Stringer

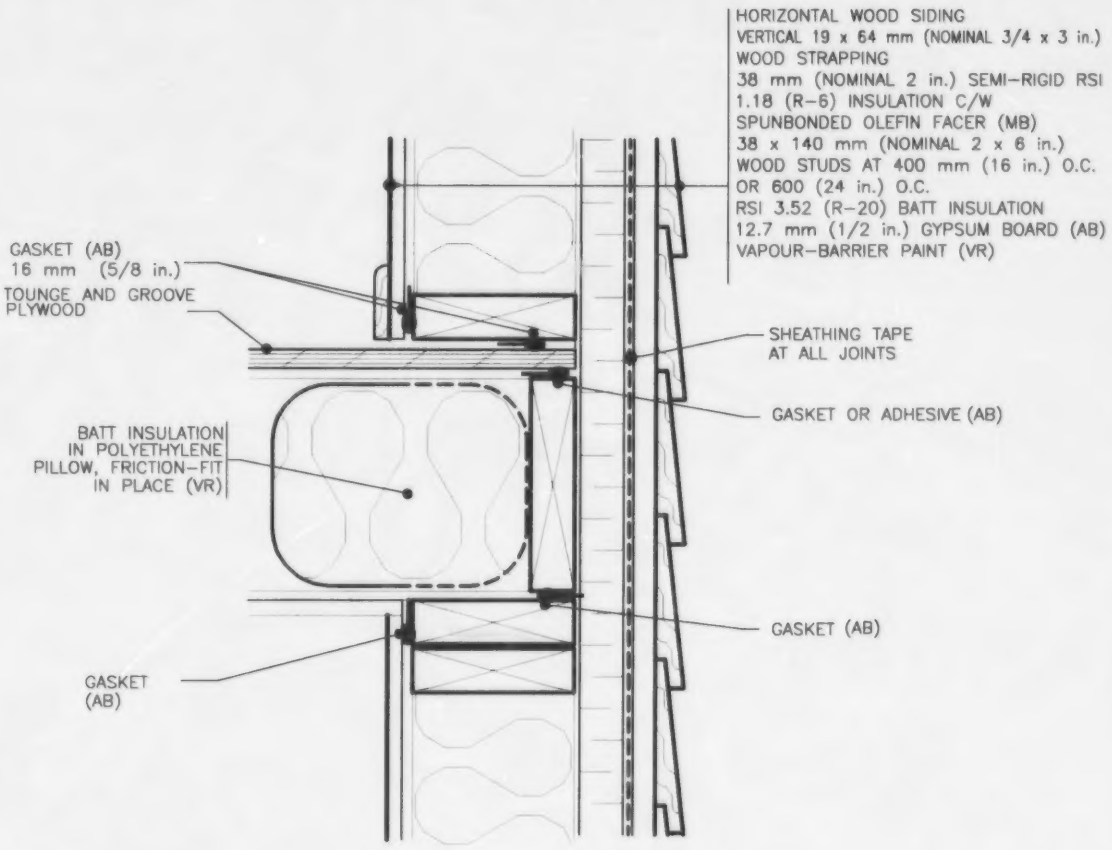

HORIZONTAL WOOD SIDING
VERTICAL 19 x 64 mm (NOMINAL 3/4 x 3 in.) WOOD STRAPPING
38 mm (NOMINAL 2 in.) SEMI-RIGID RSI 1.18 (R-8) INSULATION C/W SPUNBONDED OLEFIN FACER (MB)
38 x 140 mm (NOMINAL 2 x 6 in.) WOOD STUDS AT 400 mm (16 in.) O.C. OR 600 mm. (24 in.) O.C.
RSI 3.52 (R-20) BATT INSULATION
12.7 mm (1/2 in.) GYPSUM BOARD (AB)
VAPOUR-BARRIER PAINT (VR)
GASKET (AB)
16 mm (5/8 in.) TOUNGE AND GROOVE PLYWOOD
SHEATHING TAPE AT ALL JOINTS
GASKET OR FLOOR ADHESIVE (AB)
BATT INSULATION IN POLYETHYLENE PILLOW, FRICTION-FIT IN PLACE(VR)
PLYWOOD FILLER
INSECT SCREEN
PARGING
COMPRESSED SILL GASKET (AB)
200 mm (8 in.) MIN.
GRADE
RIGID MINERAL-FIBRE DRAINAGE LAYER
DAMPPROOFING
200 mm (8 in.) POURED CONCRETE FOUNDATION WALL
0.15 mm (6 mil.) POLYETHYLENE (MB) PERFORATED ABOVE GRADE
RSI 2.11 (R-12) BATT INSULATION
12.7 mm (1/2 in.) GYPSUM BOARD
VAPOUR-BARRIER PAINT (VR)

WOOD SIDING WALL AT FOUNDATION DETAILS

7

SCALE: 1:5 **EXTERIOR ADA INSULATION SYSTEM (WALL ASSEMBLY B)**

Detail 7: Wood Siding Wall at Foundation

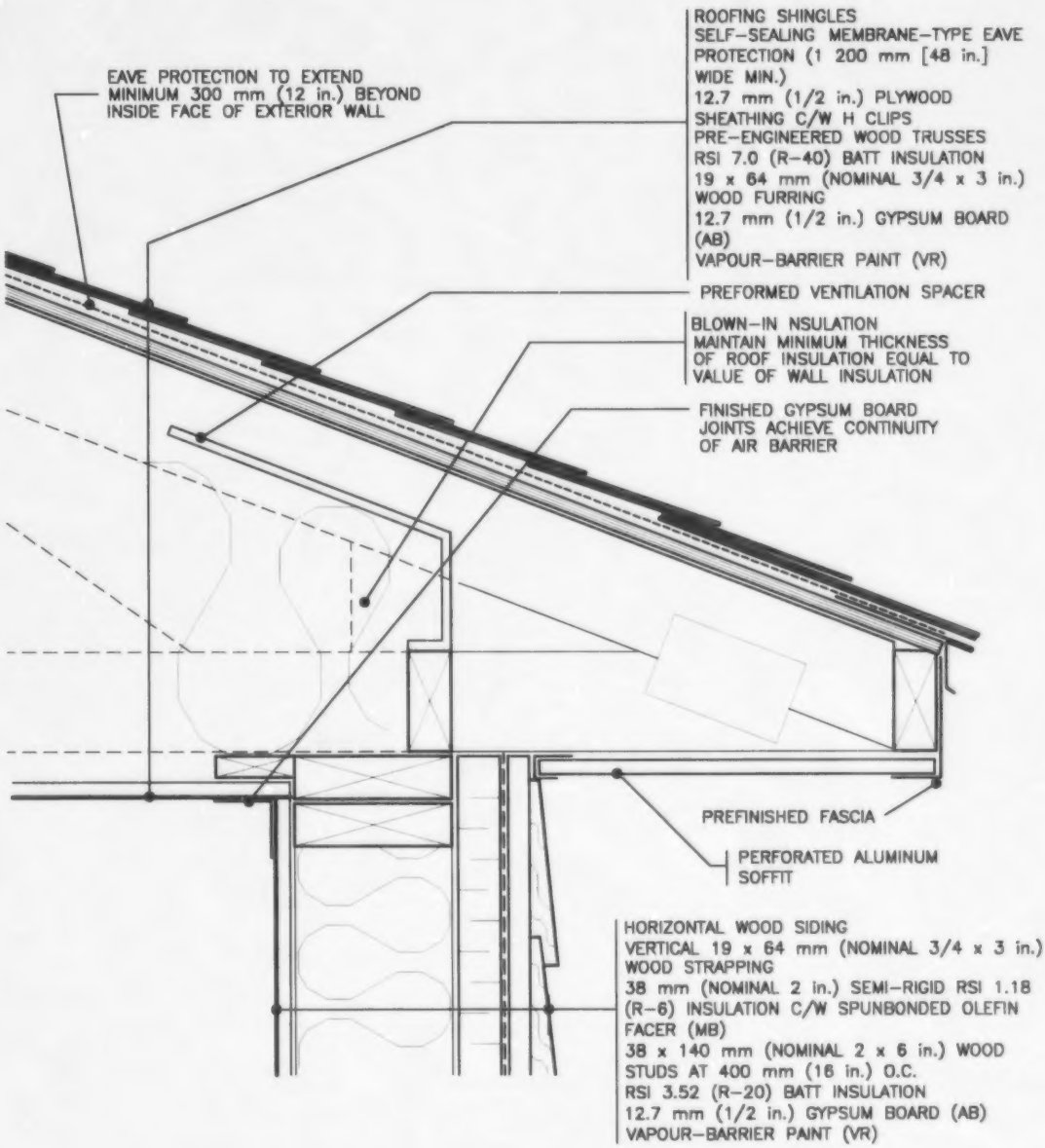


WOOD SIDING WALL AT FLOOR

SCALE: 1:5 **EXTERIOR ADA INSULATION SYSTEM (WALL ASSEMBLY B)**

8

Detail 8: Wood Siding Wall at Floor

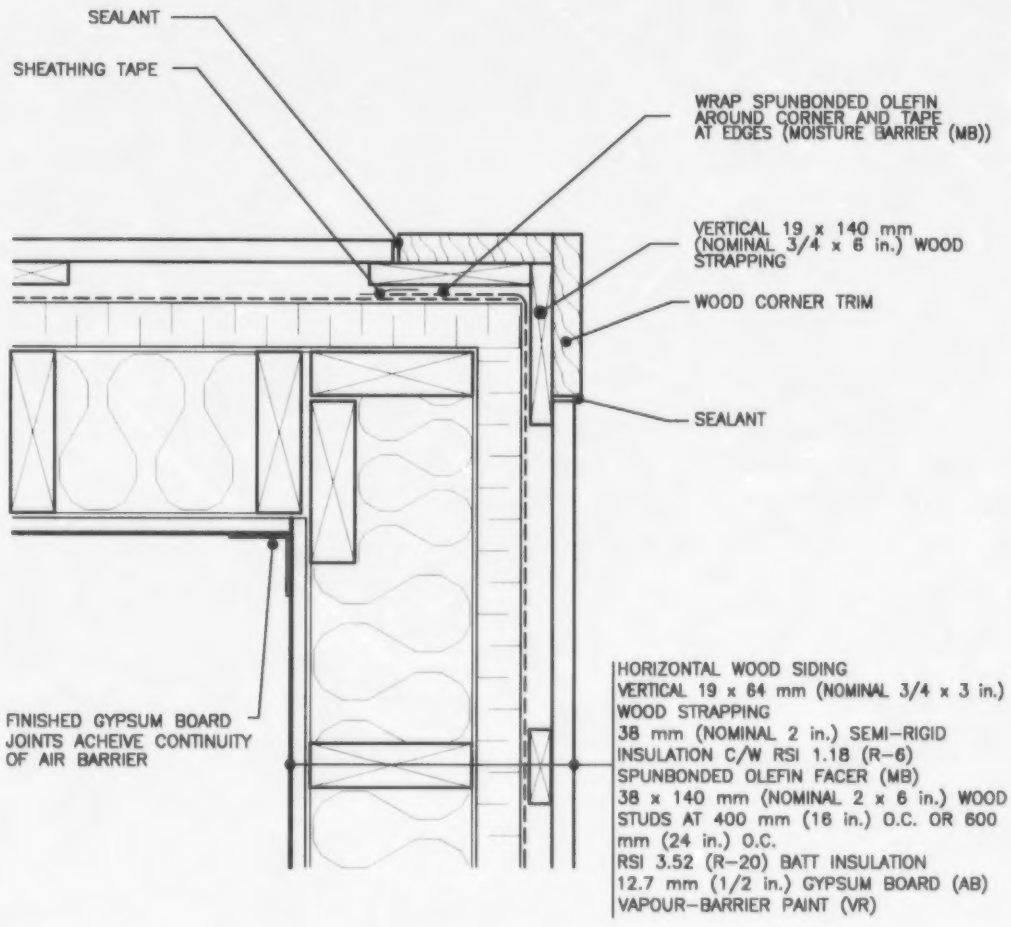

ROOFING SHINGLES
SELF-SEALING MEMBRANE-TYPE EAVE PROTECTION (1 200 mm [48 in.] WIDE MIN.)
12.7 mm (1/2 in.) PLYWOOD SHEATHING C/W H CLIPS
PRE-ENGINEERED WOOD TRUSSES
RSI 7.0 (R-40) BATT INSULATION
19 x 64 mm (NOMINAL 3/4 x 3 in.) WOOD FURRING
12.7 mm (1/2 in.) GYPSUM BOARD (AB)
VAPOUR-BARRIER PAINT (VR)
EAVE PROTECTION TO EXTEND MINIMUM 300 mm (12 in.) BEYOND INSIDE FACE OF EXTERIOR WALL
PREFORMED VENTILATION SPACER
BLOWN-IN NSULATION MAINTAIN MINIMUM THICKNESS OF ROOF INSULATION EQUAL TO VALUE OF WALL INSULATION
FINISHED GYPSUM BOARD JOINTS ACHIEVE CONTINUITY OF AIR BARRIER
PREFINISHED FASCIA
PERFORATED ALUMINUM SOFFIT
HORIZONTAL WOOD SIDING
VERTICAL 19 x 64 mm (NOMINAL 3/4 x 3 in.) WOOD STRAPPING
38 mm (NOMINAL 2 in.) SEMI-RIGID RSI 1.18 (R-6) INSULATION C/W SPUNBONDED OLEFIN FACER (MB)
38 x 140 mm (NOMINAL 2 x 6 in.) WOOD STUDS AT 400 mm (16 in.) O.C.
RSI 3.52 (R-20) BATT INSULATION
12.7 mm (1/2 in.) GYPSUM BOARD (AB)
VAPOUR-BARRIER PAINT (VR)

WOOD SIDING WALL AT ROOF

SCALE: 1:5 **EXTERIOR ADA INSULATION SYSTEM (WALL ASSEMBLY B)**

9

Detail 9: Wood Siding Wall at Roof


SEALANT
SHEATHING TAPE
WRAP SPUNBONDED OLEFIN AROUND CORNER AND TAPE AT EDGES (MOISTURE BARRIER (MB))
VERTICAL 19 x 140 mm (NOMINAL 3/4 x 6 in.) WOOD STRAPPING
WOOD CORNER TRIM
SEALANT
FINISHED GYPSUM BOARD JOINTS ACHEIVE CONTINUITY OF AIR BARRIER
HORIZONTAL WOOD SIDING
VERTICAL 19 x 64 mm (NOMINAL 3/4 x 3 in.) WOOD STRAPPING
38 mm (NOMINAL 2 in.) SEMI-RIGID INSULATION C/W RSI 1.18 (R-6)
SPUNBONDED OLEFIN FACER (MB)
38 x 140 mm (NOMINAL 2 x 6 in.) WOOD STUDS AT 400 mm (16 in.) O.C. OR 600 mm (24 in.) O.C.
RSI 3.52 (R-20) BATT INSULATION
12.7 mm (1/2 in.) GYPSUM BOARD (AB)
VAPOUR-BARRIER PAINT (VR)

CORNER, HORIZONTAL SECTION

SCALE: 1:5 EXTERIOR ADA INSULATION SYSTEM (WALL ASSEMBLY B)

10

Detail 10: Corner, Horizontal Section

WALL ASSEMBLY C

EXTERIOR AIRTIGHT SHEATHING ELEMENT (EASE) DETAILS 11, 12, 13 AND 14

We suggest this system as an alternative approach. It has been employed in a limited number of research buildings and has shown considerable promise for ease of construction and for air-barrier performance.

The exterior sheathing consists of two layers of fibreboard sheathing with a spunbonded polyolefin sheathing membrane (Tyvek) sandwiched in between.

Air Barrier

The wall air barrier is provided by the EASE sheathing system. At the ceiling level, the air barrier consists of gypsum board.

Continuity of the air barrier between the ceiling and wall assembly is maintained by wrapping spunbonded polyolefin through the top plate and gasketing it to the ceiling gypsum board.

Vapour Retarder

The vapour retarder consists of a layer of 0.05-mm (2-mil) polyethylene on the interior of the wall assembly. At the ceiling level the vapour retarder is provided by a layer of polyethylene. Due to the low vapour permeability of the wall sheathing, consider using a Type II vapour retarder with this assembly.

Advantages

Locating the air barrier on the outside of the wall assembly avoids problems with air barrier discontinuities. The ability to apply this continuous air barrier from the exterior may also make it ideal for retrofits of existing structures.

No special details are required to deal with electrical wiring, partitions, bathtubs, stairs or other interruptions of the interior finish, because the air barrier is at the exterior of the wall.

The fibreboard panels used on the exterior of an EASE assembly have a high water vapour permeability compared to sheathings such as plywood and OSB, foamed plastic and polyethylene-laminated fibreboard. This high permeability allows greater moisture diffusion through the sheathing and is preferable where framing lumber is wet.

Disadvantages

EASE requires more labour and material than the other methods, as two layers of sheathing must be installed.

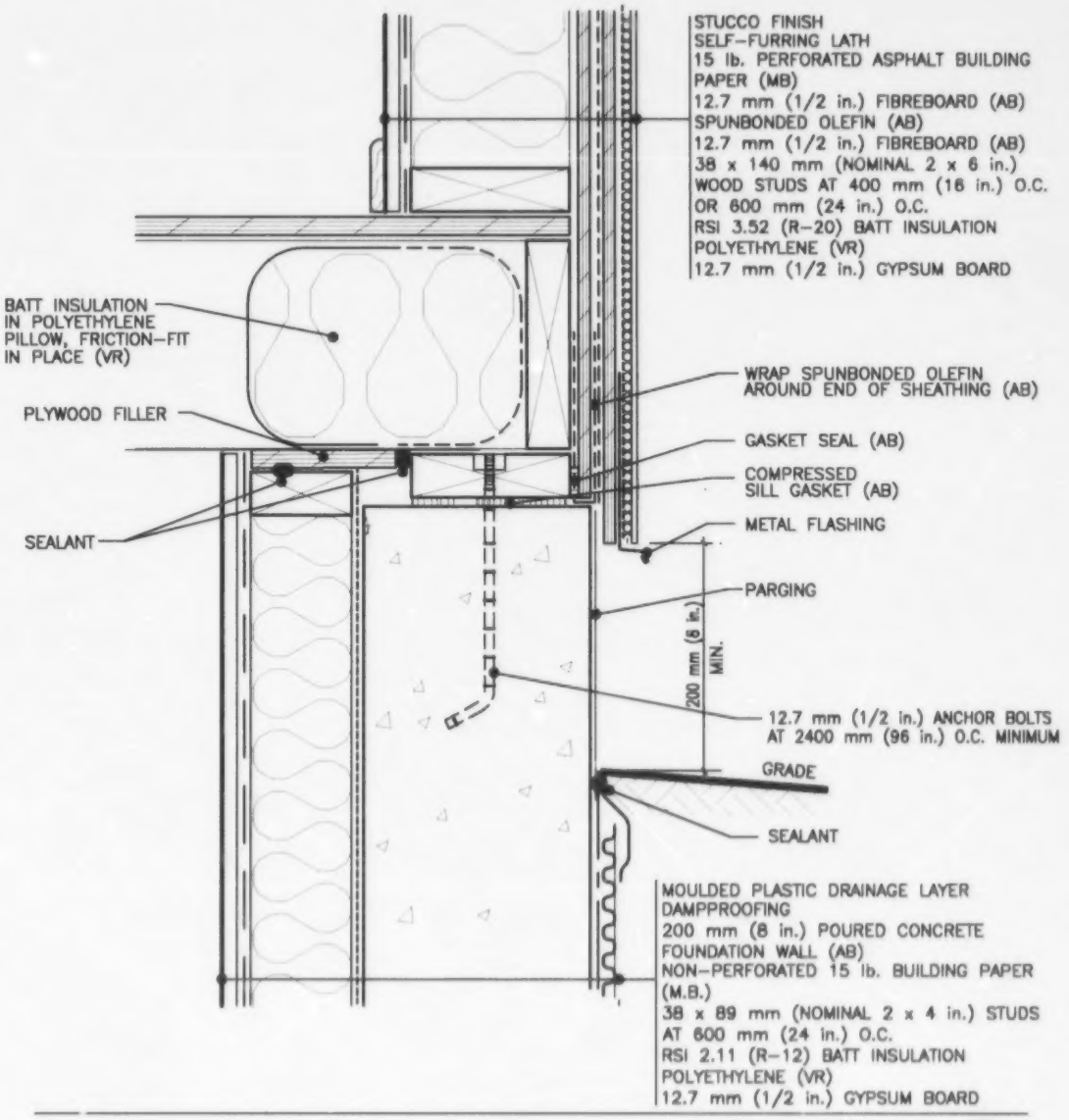
Designer's Checklist

- Detail wall sheathing joints to allow both layers of sheathing to be installed while the wall is being assembled on the floor platform (see Detail 12 for lapping system).

- Specify that the first layer of wall sheathing is to be tacked in place with 30-mm (1 1/8-in.) roofing nails. The second layer is to be fully nailed with 64-mm (2 1/2-in.) roofing nails. Space the nails at 150 mm (6 in.) at the edges and 305 mm (12 in.) o.c. along the intermediate supports.
- The sheathing membrane may be sealed to the sill plate with butyl glazing tape or an EPDM gasket. Specify that a gasket must be used for construction in freezing weather.
- As an option, 15.9-mm (5/8-in.) gypsum board nailed directly to the roof members can be used instead of the detail shown (furring strips and 12.7-mm (1/2-in.) gypsum board under the roof members). However, the furring strips help to provide a regular nailing base and a space inside the air barrier for passing electrical wiring.
- Refer to previous assemblies.

Builder's Checklist

- Ensure that framers understand the sequence of operations necessary to achieve the correct wall sheathing installation.
- Install strips of sheathing membrane to framing to achieve air barrier continuity at foundation and roof levels.
- Refer to previous assemblies regarding flashings and roofings.

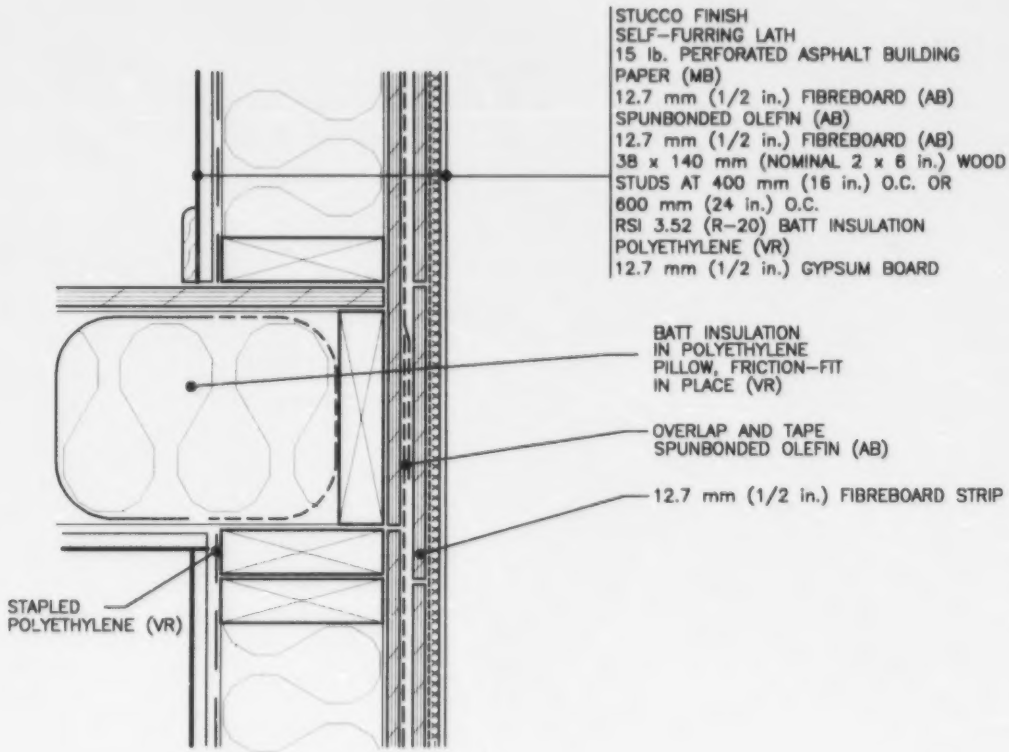

STUCCO FINISH
SELF–FURRING LATH
15 lb. PERFORATED ASPHALT BUILDING PAPER (MB)
12.7 mm (1/2 in.) FIBREBOARD (AB)
SPUNBONDED OLEFIN (AB)
12.7 mm (1/2 in.) FIBREBOARD (AB)
38 x 140 mm (NOMINAL 2 x 6 in.) WOOD STUDS AT 400 mm (16 in.) O.C. OR 600 mm (24 in.) O.C.
RSI 3.52 (R–20) BATT INSULATION
POLYETHYLENE (VR)
12.7 mm (1/2 in.) GYPSUM BOARD
BATT INSULATION IN POLYETHYLENE PILLOW, FRICTION–FIT IN PLACE (VR)
PLYWOOD FILLER
SEALANT
WRAP SPUNBONDED OLEFIN AROUND END OF SHEATHING (AB)
GASKET SEAL (AB)
COMPRESSED SILL GASKET (AB)
METAL FLASHING
PARGING
200 mm (8 in.) MIN.
12.7 mm (1/2 in.) ANCHOR BOLTS AT 2400 mm (96 in.) O.C. MINIMUM
GRADE
SEALANT
MOULDED PLASTIC DRAINAGE LAYER
DAMPPROOFING
200 mm (8 in.) POURED CONCRETE FOUNDATION WALL (AB)
NON–PERFORATED 15 lb. BUILDING PAPER (M.B.)
38 x 89 mm (NOMINAL 2 x 4 in.) STUDS AT 600 mm (24 in.) O.C.
RSI 2.11 (R–12) BATT INSULATION
POLYETHYLENE (VR)
12.7 mm (1/2 in.) GYPSUM BOARD

STUCCO CLAD WALL AT FOUNDATION
SCALE: 1:5

EASE SYSTEM (WALL ASSEMBLY C)

11

Detail 11: Stucco Clad Wall at Foundation


STUCCO FINISH
SELF–FURRING LATH
15 lb. PERFORATED ASPHALT BUILDING PAPER (MB)
12.7 mm (1/2 in.) FIBREBOARD (AB)
SPUNBONDED OLEFIN (AB)
12.7 mm (1/2 in.) FIBREBOARD (AB)
38 x 140 mm (NOMINAL 2 x 6 in.) WOOD STUDS AT 400 mm (16 in.) O.C. OR 600 mm (24 in.) O.C.
RSI 3.52 (R–20) BATT INSULATION
POLYETHYLENE (VR)
12.7 mm (1/2 in.) GYPSUM BOARD
BATT INSULATION IN POLYETHYLENE PILLOW, FRICTION–FIT IN PLACE (VR)
OVERLAP AND TAPE SPUNBONDED OLEFIN (AB)
12.7 mm (1/2 in.) FIBREBOARD STRIP
STAPLED POLYETHYLENE (VR)

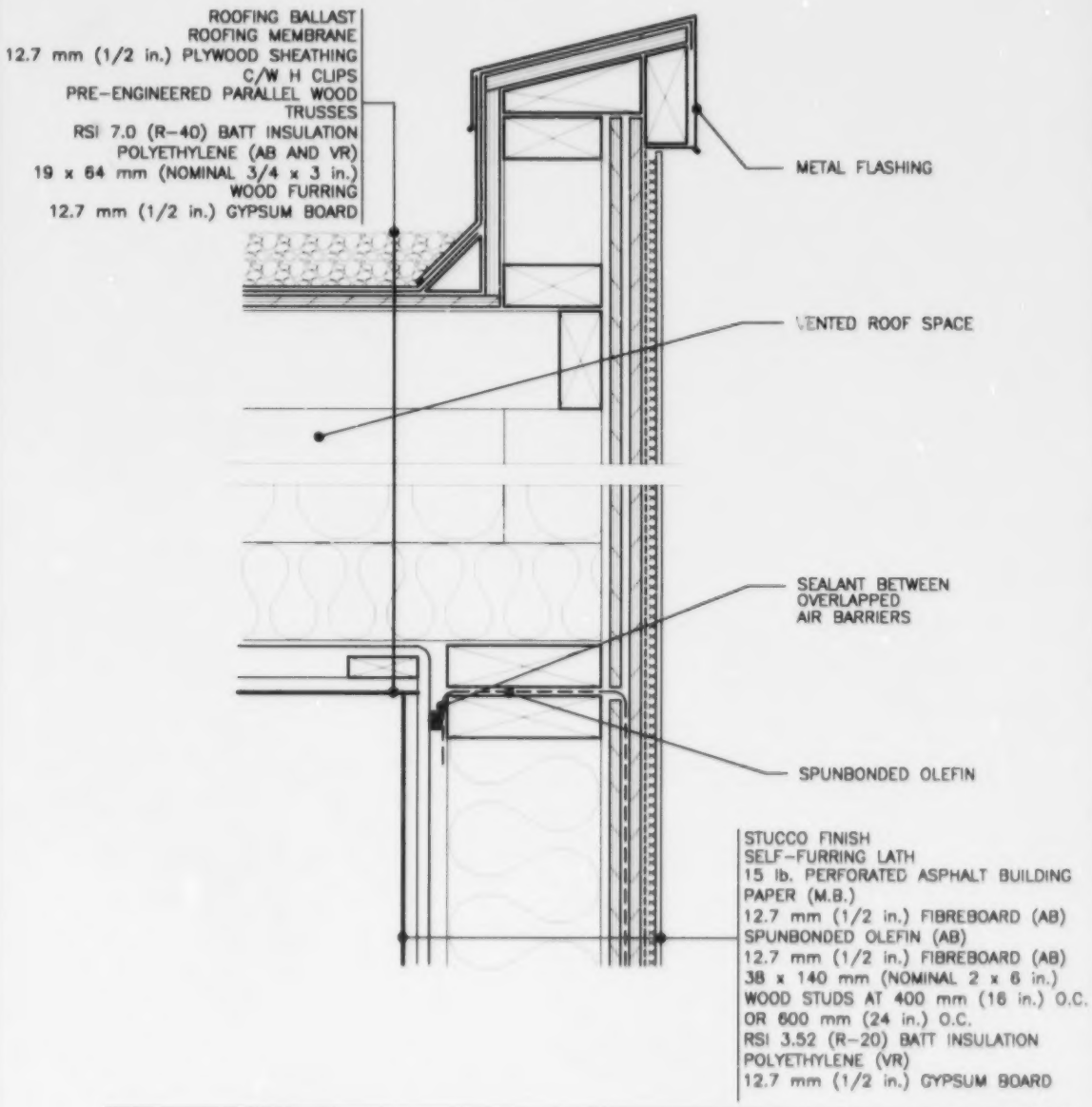
STUCCO CLAD WALL AT FLOOR

SCALE: 1:5

EASE SYSTEM (WALL ASSEMBLY C)

12

Detail 12: Stucco Clad Wall at Floor

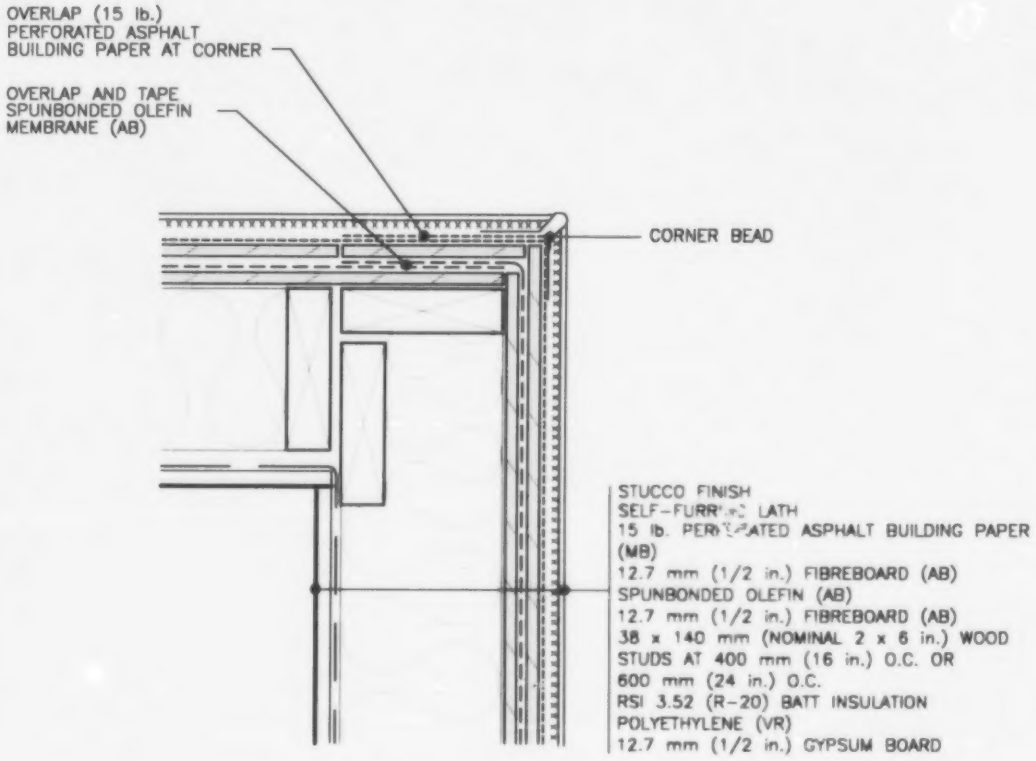

ROOFING BALLAST
ROOFING MEMBRANE
12.7 mm (1/2 in.) PLYWOOD SHEATHING
C/W H CLIPS
PRE-ENGINEERED PARALLEL WOOD TRUSSES
RSI 7.0 (R-40) BATT INSULATION
POLYETHYLENE (AB AND VR)
19 x 64 mm (NOMINAL 3/4 x 3 in.) WOOD FURRING
12.7 mm (1/2 in.) GYPSUM BOARD
METAL FLASHING
VENTED ROOF SPACE
SEALANT BETWEEN OVERLAPPED AIR BARRIERS
SPUNBONDED OLEFIN
STUCCO FINISH
SELF-FURRING LATH
15 lb. PERFORATED ASPHALT BUILDING PAPER (M.B.)
12.7 mm (1/2 in.) FIBREBOARD (AB)
SPUNBONDED OLEFIN (AB)
12.7 mm (1/2 in.) FIBREBOARD (AB)
38 x 140 mm (NOMINAL 2 x 6 in.) WOOD STUDS AT 400 mm (16 in.) O.C. OR 600 mm (24 in.) O.C.
RSI 3.52 (R-20) BATT INSULATION
POLYETHYLENE (VR)
12.7 mm (1/2 in.) GYPSUM BOARD

STUCCO CLAD WALL AT ROOF
SCALE: 1:5

EASE SYSTEM (WALL ASSEMBLY C)

13

Detail 13: Stucco Clad Wall at Roof


OVERLAP (15 lb.)
PERFORATED ASPHALT
BUILDING PAPER AT CORNER
OVERLAP AND TAPE
SPUNBONDED OLEFIN
MEMBRANE (AB)
CORNER BEAD
STUCCO FINISH
SELF-FURRING LATH
15 lb. PERFORATED ASPHALT BUILDING PAPER
(MB)
12.7 mm (1/2 in.) FIBREBOARD (AB)
SPUNBONDED OLEFIN (AB)
12.7 mm (1/2 in.) FIBREBOARD (AB)
38 x 140 mm (NOMINAL 2 x 6 in.) WOOD
STUDS AT 400 mm (16 in.) O.C. OR
600 mm (24 in.) O.C.
RSI 3.52 (R-20) BATT INSULATION
POLYETHYLENE (VR)
12.7 mm (1/2 in.) GYPSUM BOARD

CORNER, HORIZONTAL SECTION

SCALE: 1:5

EASE SYSTEM (WALL ASSEMBLY C)

14

Detail 14: Corner, Horizontal Section

WALL ASSEMBLY A, B AND C (BELOW GRADE)

DETAILS 15 AND 16

The principal components and functions of the foundation details are as follows:

Poured concrete or concrete block structure: Concrete provides its own air barrier. Block is porous and must be parged to create an air barrier and suitable base for application of dampproofing.

Floor Slab: Acts as an air barrier. Must be sealed to the wall to provide continuity of the barrier.

Dampproofing: Prevents wicking of moisture into the structure.

Drainage Layer: May consist of free-draining backfill, dimpled plastic or geotextile composite board or insulation board. Allows free water to drain directly to footing level.

Perimeter Drainage Tile: Moves water away from the foundation and ensures that hydrostatic pressure will not occur at slab level. Gravel cover is required to allow water to flow from drainage layer to weeper and to keep free soil particles away from drainage tiles.

Dampproofing Course: Prevents wicking of moisture into the foundation wall.

Thermal Insulation: Thermal insulation may be installed entirely on the inner wall face or entirely on the outer face, or on both.

Air Barrier

The poured concrete wall forms part of the air barrier system. Alternatively, the parging on the concrete block may provide an air barrier. (Concrete block alone does not constitute an air barrier).

The floor slab is sealed to the wall at the perimeter for air-barrier continuity.

Vapour Retarder

A vapour retarder is provided on the interior of the wall insulation.

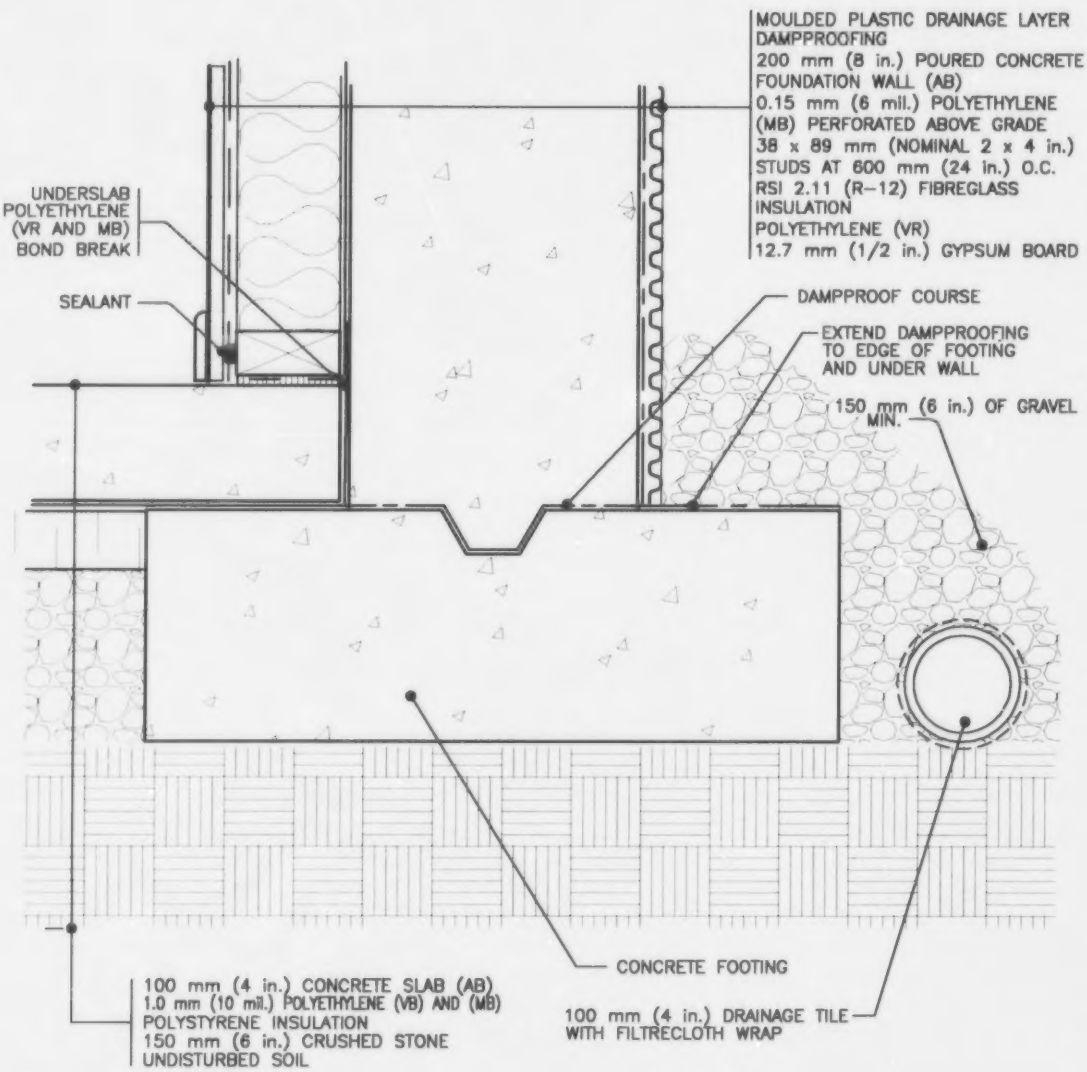
It is recommended that polyethylene be installed below the floor slabs.

Designer's Checklist

- Verify the depth of frost penetration, and design the foundation depth accordingly. (Specify mechanical attachment of external insulation to prevent frost heave).
- In the proposed detail, 0.15-mm (6-mil.) polyethylene rather than a thinner sheet has been used to prevent accidental tears from the rough concrete. Other dampproofing materials may be used.
- Specify a dampproof course over the footing to reduce moisture transfer by capillary action from ground water.
- Specify urethane sealant for wall or slab caulking.

Builder's Checklist

- Avoid damaging or displacing the polyethylene sheet and the rigid insulation while pouring the floor slab.
- Ensure that perimeter drainage has sufficient cover to operate correctly.

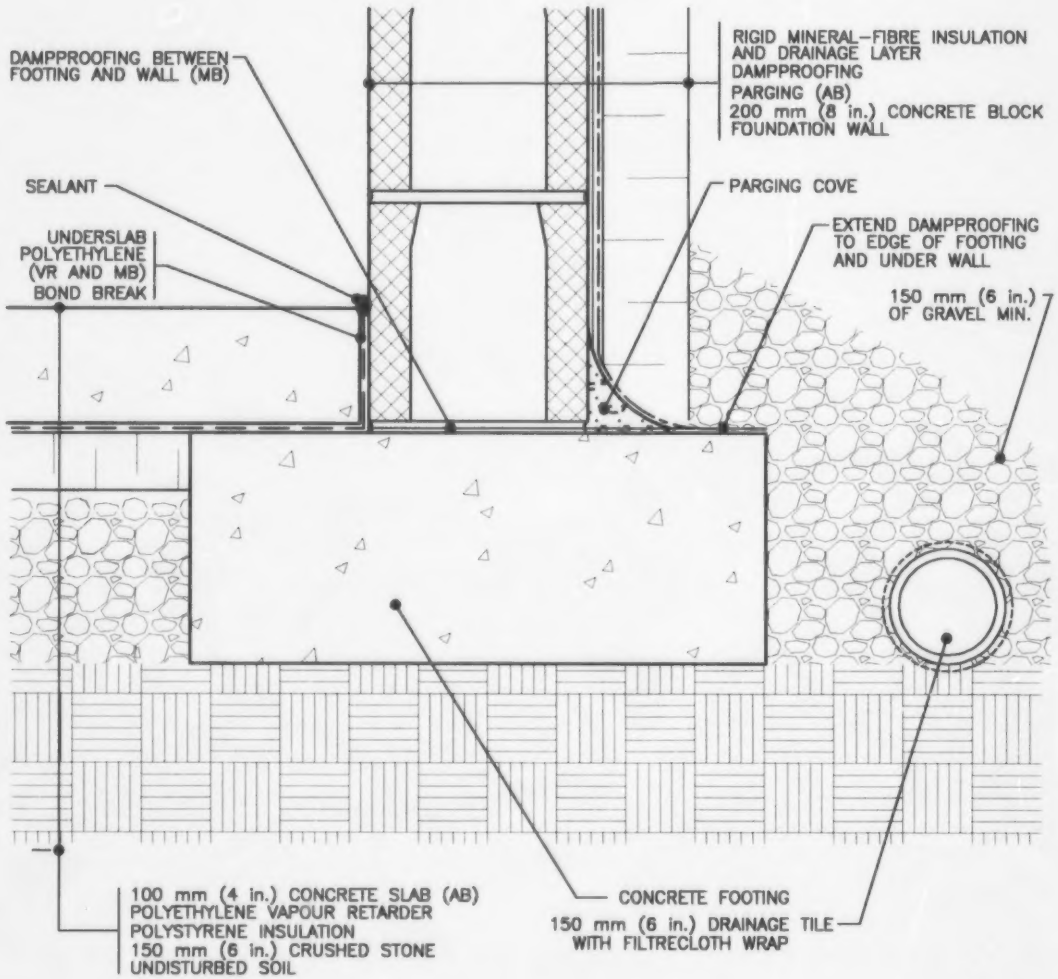

MOULDED PLASTIC DRAINAGE LAYER
DAMPPROOFING
200 mm (8 in.) POURED CONCRETE FOUNDATION WALL (AB)
0.15 mm (6 mil.) POLYETHYLENE (MB) PERFORATED ABOVE GRADE
38 x 89 mm (NOMINAL 2 x 4 in.) STUDS AT 600 mm (24 in.) O.C.
RSI 2.11 (R-12) FIBREGLASS INSULATION
POLYETHYLENE (VR)
12.7 mm (1/2 in.) GYPSUM BOARD
UNDERSLAB POLYETHYLENE (VR AND MB) BOND BREAK
SEALANT
DAMPPROOF COURSE
EXTEND DAMPPROOFING TO EDGE OF FOOTING AND UNDER WALL
150 mm (6 in.) OF GRAVEL MIN.
CONCRETE FOOTING
100 mm (4 in.) CONCRETE SLAB (AB)
1.0 mm (10 mil.) POLYETHYLENE (VB) AND (MB)
POLYSTYRENE INSULATION
150 mm (6 in.) CRUSHED STONE
UNDISTURBED SOIL
100 mm (4 in.) DRAINAGE TILE WITH FILTRECLOTH WRAP

FOUNDATION WALL AT SLAB

SCALE: 1:5 (WALL ASSEMBLIES A, B, AND C)

15

Detail 15: Foundation Wall at Slab


DAMPPROOFING BETWEEN FOOTING AND WALL (MB)
SEALANT
UNDERSLAB POLYETHYLENE (VR AND MB)
BOND BREAK
RIGID MINERAL–FIBRE INSULATION AND DRAINAGE LAYER
DAMPPROOFING
PARGING (AB)
200 mm (8 in.) CONCRETE BLOCK FOUNDATION WALL
PARGING COVE
EXTEND DAMPPROOFING TO EDGE OF FOOTING AND UNDER WALL
150 mm (6 in.) OF GRAVEL MIN.
100 mm (4 in.) CONCRETE SLAB (AB)
POLYETHYLENE VAPOUR RETARDER
POLYSTYRENE INSULATION
150 mm (6 in.) CRUSHED STONE
UNDISTURBED SOIL
CONCRETE FOOTING
150 mm (6 in.) DRAINAGE TILE WITH FILTRECLOTH WRAP

FOUNDATION WALL AT SLAB

SCALE: 1:5

(WALL ASSEMBLIES A, B, AND C)

16

Detail 16: Foundation Wall at Slab

WINDOW OPENINGS

The perimeter of window and door openings has been a location of significant air leakage.

Where masonry veneer cladding is used, allow for differential movement and shrinkage between the wood structure and the masonry. In a three- or four-storey building, the amount of movement due to the initial drying of the wood framing may be up to 20 mm (3/4 in.). A window anchored in the wood structure will move relative to the masonry. Therefore, the joints between the window and the masonry must allow for this movement. Caulking may fail rapidly due to shear or elongation. At the window sill, the movement may be in excess of what a caulked joint can accommodate. In that case, a flexible metal flashing as shown in Detail 17 may be used.

WINDOW OPENING–WALL ASSEMBLY A–DETAIL 17

This detail illustrates a method of creating air-barrier continuity for Wall Assembly A in which polyethylene is the primary element of the air-barrier system. Sprayed foam is the preferred method of sealing the gap between the rough stud opening and the window frame.

Air Barrier

The polyethylene must be sealed to the rough stud opening window assembly to create continuity in the air-barrier assembly.

Some windows are now available with air-barrier flanges. If you use this type of window, seal it to the air-barrier element in the wall.

Vapour Retarder

In this wall assembly, the polyethylene constitutes the vapour retarder.

Flashings

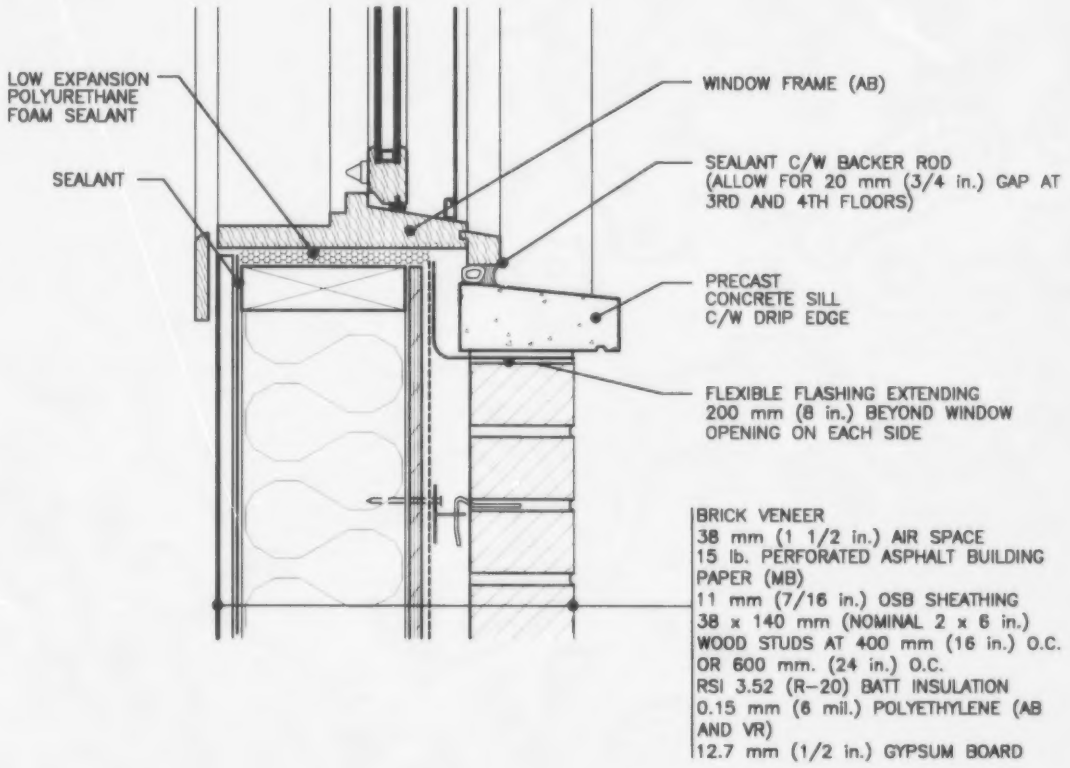
Flashings must be provided at the window head and below any jointed sill assembly.

Designer's Checklist

- Ensure that the air barrier is continuous in the assembly. Examine the window frame profile and type and select the appropriate window sealing system.
- Determine the possible cumulative effect of shrinkage of the wood framing and select sill details accordingly. Size caulking joints around windows to accommodate the anticipated movement.
- Review window shop drawings to reconfirm applicability of design details.

Builder's Checklist

- Verify the type of window or air-barrier sealant system before you install the windows.
- Leave the appropriate tolerances between window and wood frames, and between window and cladding elements.
- Co-ordinate the installation of flashing elements with the installation of windows and the cladding system.
- Inspect the quality of seals around windows before closing in the structure.


LOW EXPANSION POLYURETHANE FOAM SEALANT
SEALANT
WINDOW FRAME (AB)
SEALANT C/W BACKER ROD (ALLOW FOR 20 mm (3/4 in.) GAP AT 3RD AND 4TH FLOORS)
PRECAST CONCRETE SILL C/W DRIP EDGE
FLEXIBLE FLASHING EXTENDING 200 mm (8 in.) BEYOND WINDOW OPENING ON EACH SIDE
BRICK VENEER
38 mm (1 1/2 in.) AIR SPACE
15 lb. PERFORATED ASPHALT BUILDING PAPER (MB)
11 mm (7/16 in.) OSB SHEATHING
38 x 140 mm (NOMINAL 2 x 6 in.) WOOD STUDS AT 400 mm (16 in.) O.C. OR 600 mm. (24 in.) O.C.
RSI 3.52 (R-20) BATT INSULATION
0.15 mm (6 mil.) POLYETHYLENE (AB AND VR)
12.7 mm (1/2 in.) GYPSUM BOARD

WINDOW OPENING

SCALE: 1:5

(WALL ASSEMBLY A)

17

Detail 17: Window Opening, A

WINDOW OPENING–WALL ASSEMBLY B–DETAIL 18

This detail illustrates a method of creating air-barrier continuity for Wall Assembly B in which gypsum board is the primary element of the air-barrier system and where gaskets are used to provide system continuity.

Air Barrier

The gypsum board must be linked to the window assembly. This is done by installing a gasket behind the gypsum board at the full perimeter of the window rough framing. The rough frame is sealed to the window frame using a sprayed-in-place urethane foam sealant.

Vapour Retarder

In this wall assembly, a vapour retarder paint is the principal vapour retarder.

Flashings

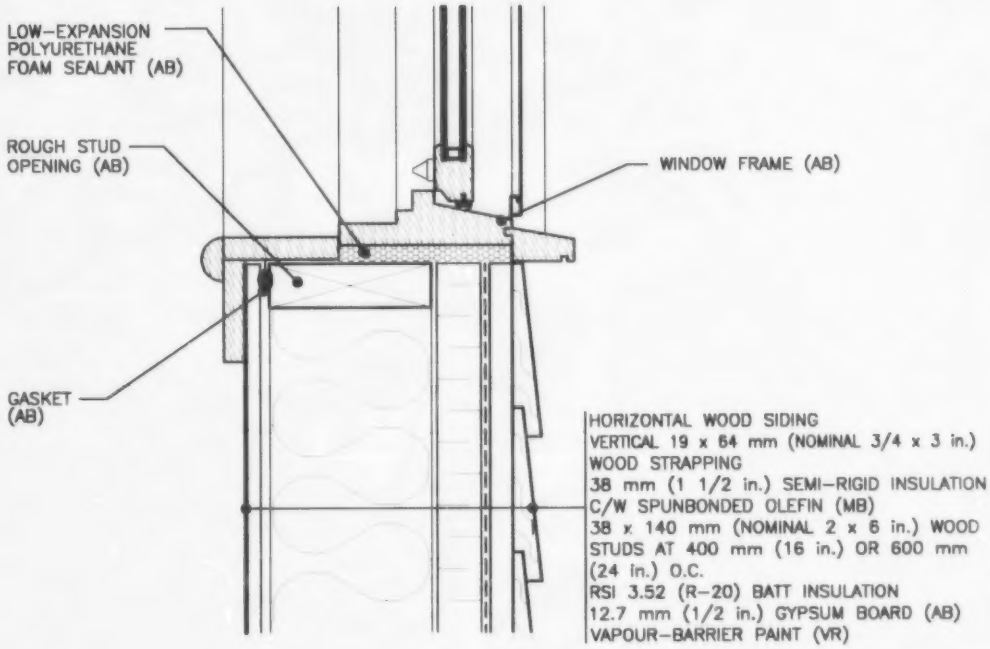
Flashings must be provided at the window head and below any jointed sill assembly.

Designer's Checklist

- Ensure that the air barrier is continuous in the assembly. Examine the window frame profile and type, and select the appropriate window sealing system.
- Determine the possible cumulative effect of shrinkage of the wood framing, and select sill details accordingly. Size caulking joints around windows to accommodate the anticipated movement.
- Review window shop drawings to reconfirm the applicability of design details.

Builder's Checklist

- Verify the type of window or air-barrier sealant system before you install the windows.
- Leave the appropriate tolerances between window and wood frames and between window and cladding elements.
- Co-ordinate the installation of flashing elements with the installation of windows and the cladding system.
- Inspect the quality of seals around windows before closing in the structure.


LOW–EXPANSION POLYURETHANE FOAM SEALANT (AB)
ROUGH STUD OPENING (AB)
GASKET (AB)
WINDOW FRAME (AB)
HORIZONTAL WOOD SIDING
VERTICAL 19 x 64 mm (NOMINAL 3/4 x 3 in.) WOOD STRAPPING
38 mm (1 1/2 in.) SEMI–RIGID INSULATION C/W SPUNBONDED OLEFIN (MB)
38 x 140 mm (NOMINAL 2 x 6 in.) WOOD STUDS AT 400 mm (16 in.) OR 600 mm (24 in.) O.C.
RSI 3.52 (R–20) BATT INSULATION
12.7 mm (1/2 in.) GYPSUM BOARD (AB)
VAPOUR–BARRIER PAINT (VR)

WINDOW OPENING

SCALE: 1:5

(WALL ASSEMBLY B)

18

Detail 18: Window Opening, B

WINDOW OPENING-WALL ASSEMBLY C-DETAIL 19

The EASE wall sheathing system provides the air barrier in this assembly.

Air Barrier

The sides of the rough opening are wrapped with a sheathing membrane. The gap around the window is sealed with low expansion polyurethane foam sealant.

Vapour Retarder

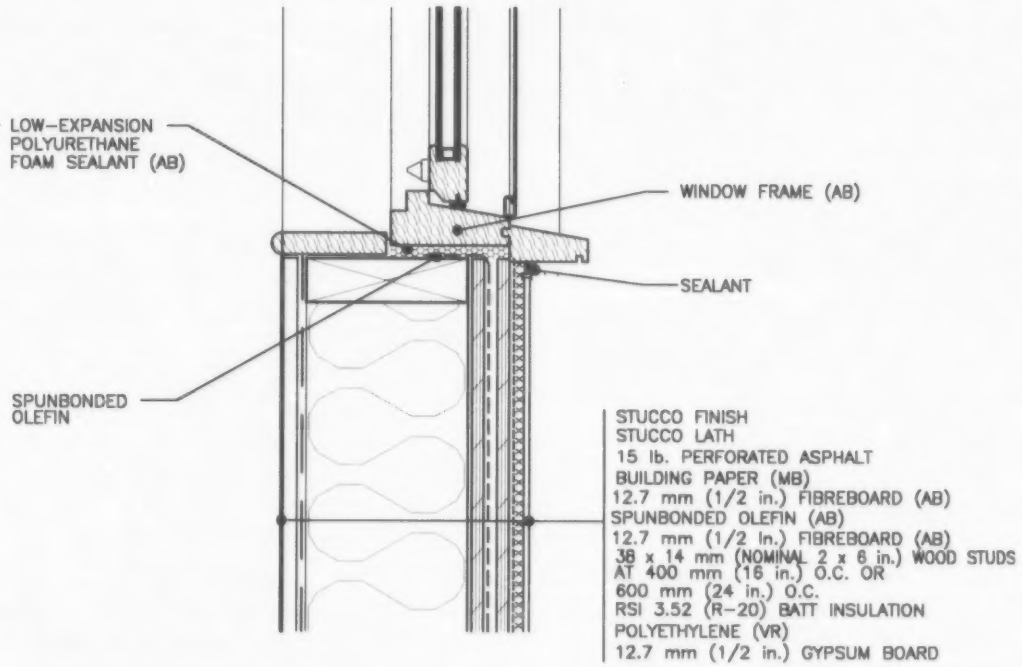
A polyethylene sheet forms the vapour retarder in this wall assembly.

Designer's Checklist

- Ensure that the air barrier is continuous in the assembly. Examine the window frame profile and type. Select the appropriate window sealing system accordingly.
- Determine the possible cumulative effect of shrinkage of the wood framing, and select sill details accordingly. Size the caulking joints around windows to accommodate the anticipated movement.
- Review the window shop drawings to reconfirm the applicability of design details.

Builder's Checklist

- Verify the type of window or air-barrier sealant system before you install the windows.
- Leave the appropriate tolerances between windows and wood frames and between windows and cladding elements.
- Co-ordinate the installation of flashing elements with the installation of windows and the cladding system.
- Inspect the quality of seals around windows before closing in the structure.
- Wrap sheathing membranes on to window rough stud openings when framing.
- Seal laps in the sheathing membrane with tape.



WINDOW OPENING

SCALE: 1:5

(WALL ASSEMBLY C)

19

Detail 19: Window Opening, C

CANTILEVERED FLOORS

Floor cantilevers are often problematic due to discontinuities in the air barrier. This leads to cold floors, heating problems and potential condensation in the overhang. Ensure that the floor area of the overhang is properly heated to avoid cold floors.

The problem is complicated when heating ducts are brought to the exterior through the overhanging floor.

Insulation should be placed in a dropped soffit below the joist space.

Three examples are illustrated which correspond to the three sample wall assemblies. However, each of the examples can be adapted for use with the other wall assemblies. It is important to verify the location of the vapour retarder and the continuity of the air-barrier assemblies.

Designer's Checklist

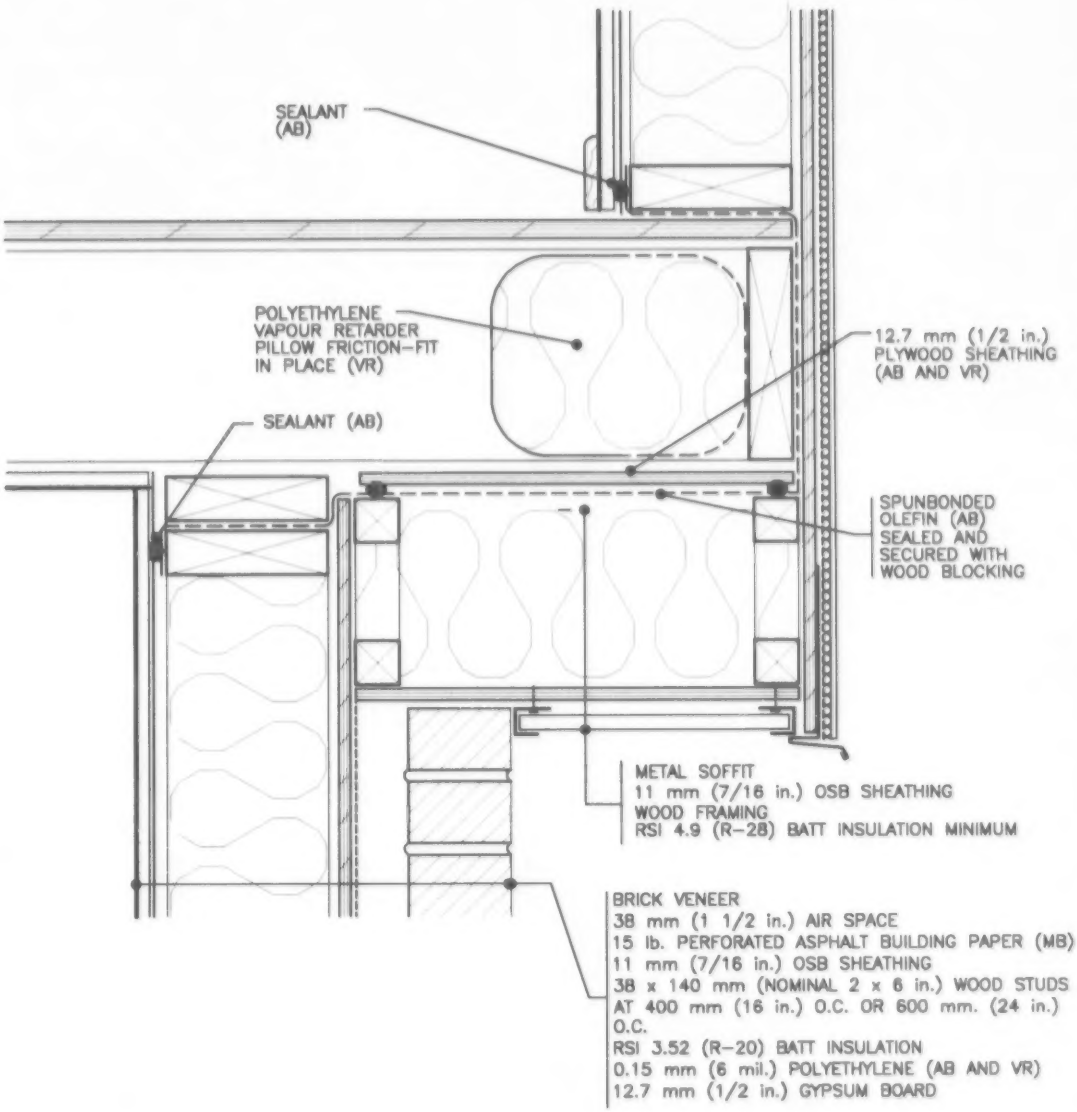
- Confirm whether the ground floor fenestration permits a dropped soffit space below the cantilever.
- Review the location of the primary air-barrier element in the walls.
- Select an overhang assembly based on the above criteria.
- Clearly identify the route of the air barrier and the way the junctions between different materials are made.

Builder's Checklist

- Review the path of the air barrier, its primary elements and joints.
- Review with the tradespeople, and coordinate the sequence of installing all blocking, insulation and seals.
- Inspect the work before closing in to ensure that seals have been made satisfactorily.
- Ensure that voids are not left in cavities that are being insulated.

CANTILEVERED FLOOR–WALL ASSEMBLY A–DETAIL 20

A spunbonded polyolefin membrane is lapped and sealed onto plywood sheathing at the underside of the overhanging floor joists. This plywood acts as an air barrier and a vapour retarder. Joints in the membrane are taped, and the membrane is sealed to the polyethylene air-barrier element in the walls with a bead of caulking. The polyethylene functions as both a vapour barrier and an air barrier.


SEALANT (AB)
POLYETHYLENE VAPOUR RETARDER PILLOW FRICTION–FIT IN PLACE (VR)
SEALANT (AB)
12.7 mm (1/2 in.) PLYWOOD SHEATHING (AB AND VR)
SPUNBONDED OLEFIN (AB) SEALED AND SECURED WITH WOOD BLOCKING
METAL SOFFIT
11 mm (7/16 in.) OSB SHEATHING
WOOD FRAMING
RSI 4.9 (R–28) BATT INSULATION MINIMUM
BRICK VENEER
38 mm (1 1/2 in.) AIR SPACE
15 lb. PERFORATED ASPHALT BUILDING PAPER (MB)
11 mm (7/16 in.) OSB SHEATHING
38 x 140 mm (NOMINAL 2 x 6 in.) WOOD STUDS AT 400 mm (16 in.) O.C. OR 600 mm. (24 in.) O.C.
RSI 3.52 (R–20) BATT INSULATION
0.15 mm (6 mil.) POLYETHYLENE (AB AND VR)
12.7 mm (1/2 in.) GYPSUM BOARD

CANTILEVERED FLOOR

SCALE: 1:5

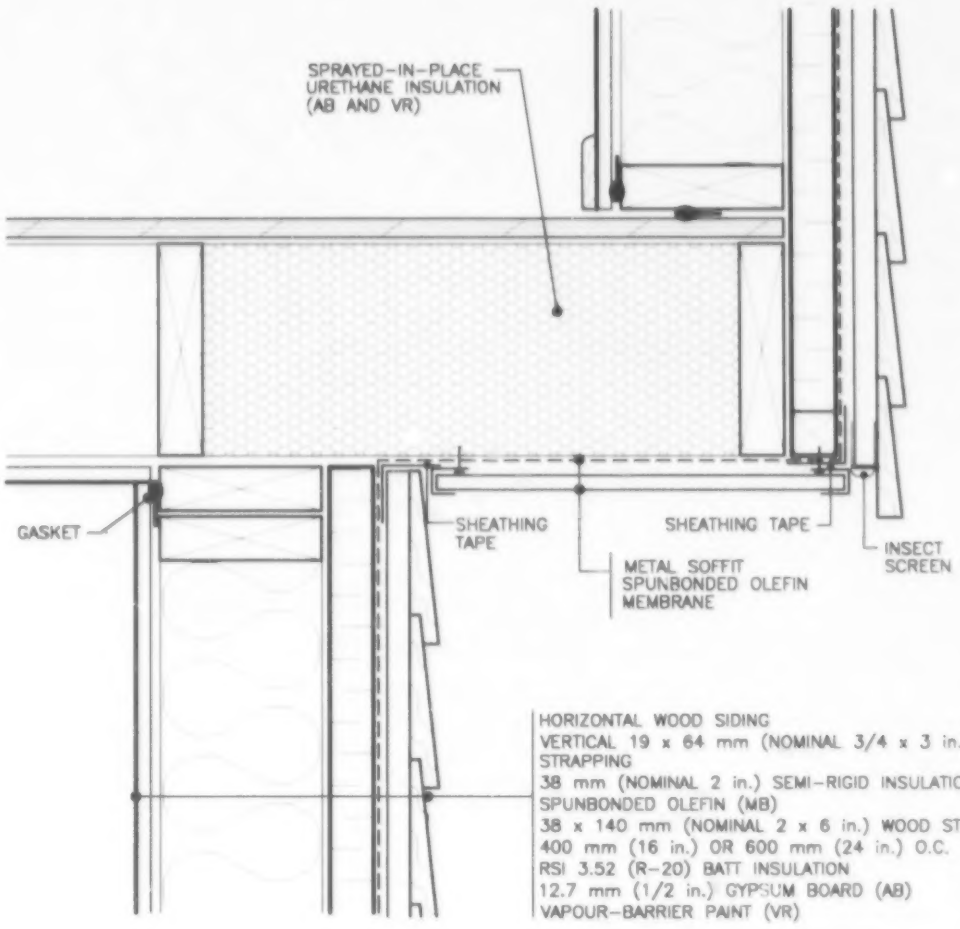
(WALL ASSEMBLY A)

20

Detail 20: Cantilevered Floor, A

CANTILEVERED FLOOR-WALL ASSEMBLY B-DETAIL 21

Sprayed-in-place polyurethane foam insulation is installed in the joist spaces. The foam acts as an effective air barrier, vapour barrier, insulation and joint sealant. Gaskets are used to connect the gypsum-board and wood-structure air-barrier elements.



CANTILEVERED FLOOR

SCALE: 1:5

(WALL ASSEMBLY B)

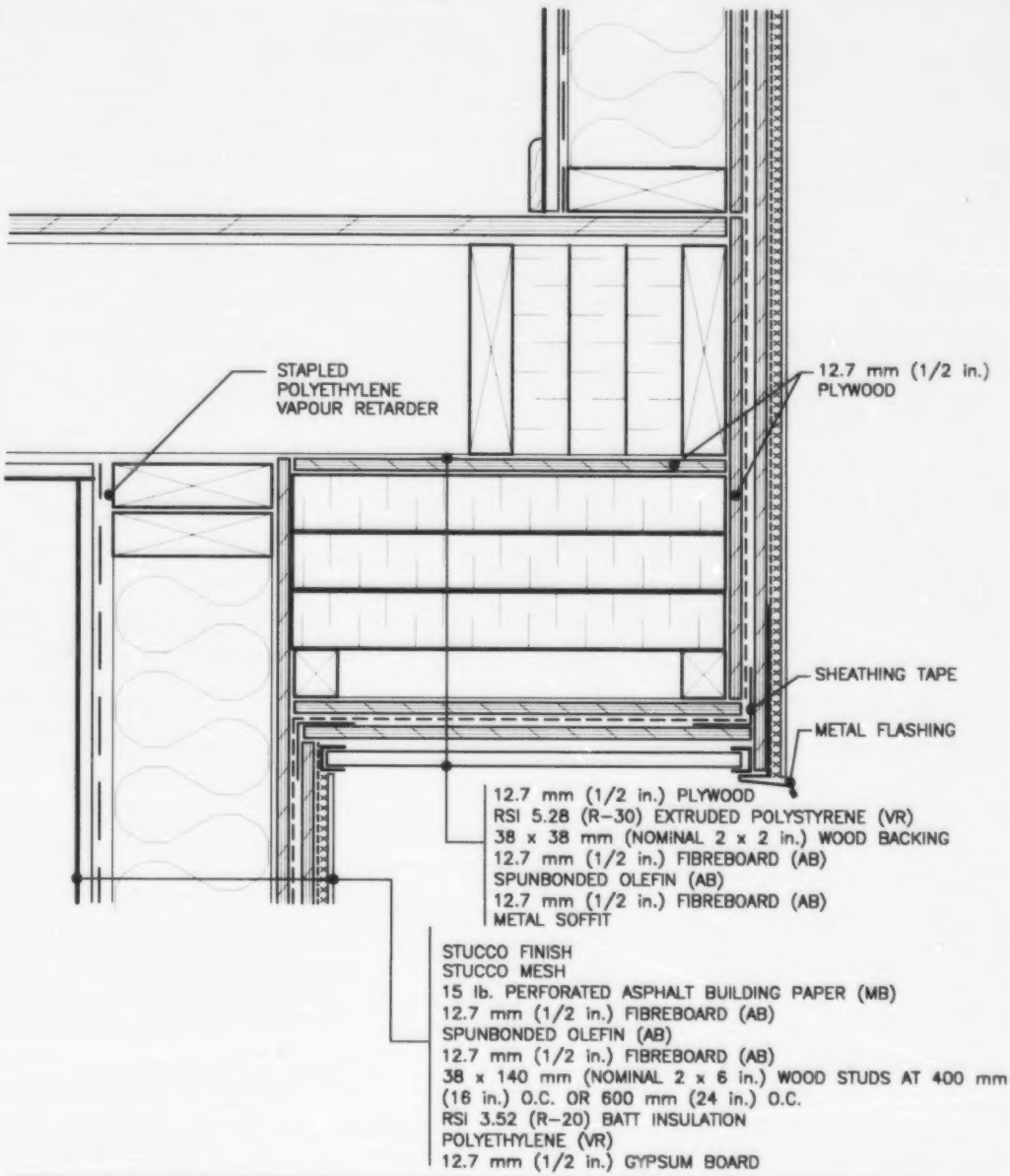
21

***Detail 21:** Cantilevered Floor, B*

CANTILEVERED FLOOR-WALL ASSEMBLY C-DETAIL 22

This detail corresponds to Wall Assembly C, where the air barrier is located at the exterior. The EASE sheathing system is extended across the overhanging soffit. Joints in the sheathing membrane are lapped and taped.

Sealing the plywood or using closed-cell extruded foam will provide a vapour barrier.


STAPLED
POLYETHYLENE
VAPOUR RETARDER
12.7 mm (1/2 in.)
PLYWOOD
SHEATHING TAPE
METAL FLASHING
12.7 mm (1/2 in.) PLYWOOD
RSI 5.28 (R–30) EXTRUDED POLYSTYRENE (VR)
38 x 38 mm (NOMINAL 2 x 2 in.) WOOD BACKING
12.7 mm (1/2 in.) FIBREBOARD (AB)
SPUNBONDED OLEFIN (AB)
12.7 mm (1/2 in.) FIBREBOARD (AB)
METAL SOFFIT
STUCCO FINISH
STUCCO MESH
15 lb. PERFORATED ASPHALT BUILDING PAPER (MB)
12.7 mm (1/2 in.) FIBREBOARD (AB)
SPUNBONDED OLEFIN (AB)
12.7 mm (1/2 in.) FIBREBOARD (AB)
38 x 140 mm (NOMINAL 2 x 6 in.) WOOD STUDS AT 400 mm
(16 in.) O.C. OR 600 mm (24 in.) O.C.
RSI 3.52 (R–20) BATT INSULATION
POLYETHYLENE (VR)
12.7 mm (1/2 in.) GYPSUM BOARD

CANTILEVERED FLOOR

SCALE: 1:5

(WALL ASSEMBLY C)

22

Detail 22: Cantilevered Floor, C

BALCONIES

COLUMN-SUPPORTED BALCONY WITH BRICK VENEER-WALL ASSEMBLY A-DETAIL 23

Notes

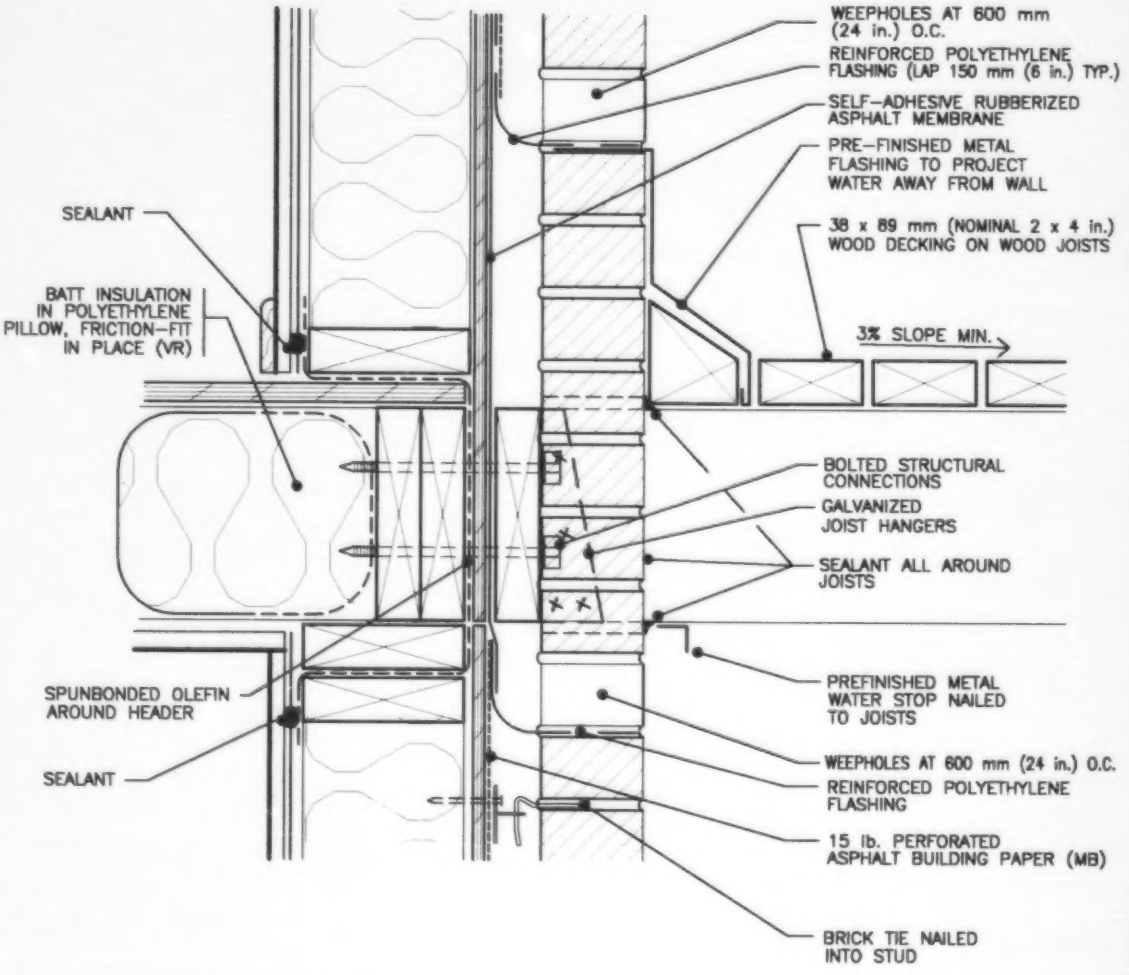
- The use of a column-supported balcony is preferable to a cantilever because joists do not extend through the wall sheathing and air barrier.
- Balcony joists are supported on a ledger bolted to the framing.
- Air-barrier continuity at the floor level may be achieved by typical wall assembly details.
- A rubberized asphalt membrane is installed behind the ledger to protect the sheathing from water and to seal around penetrations of the sheathing.
- The wood ledger is protected from wetness in the cavity by a through-wall flashing.
- The through-wall flashing is extended approximately 100 mm (4 in.) from the brick face to keep water away from the wall face, where it may enter through openings.
- A gap is left around the balcony joists where they penetrate the brick veneer to allow for differential movement. The gap is sealed with caulking and back-up rope.
- A through-wall flashing is provided below the balcony so that any water leaking into the assembly is led back out of the wall.

Designer's Checklist

- Ensure that the balcony column structure will exhibit the same cumulative shrinkage characteristics as the main wall, or allow for predicted shrinkage so that there will be drainage away from the wall.
- Locate the balcony door sill above through-wall flashing.
- Specify a brick cavity wide enough to accommodate the wood ledger.
- Specify pressure-treated wood for joists and cedar or treated wood for decking.
- Design the structural connection of the balcony to meet the load criteria.

Builder's Checklist

- Verify the foundation and framing layout to ensure that a proper wall cavity is allowed for.
- Install a self-adhesive membrane before framing the balcony.
- Coordinate the installation of through-wall flashing and protection membrane with the tradespeople.


WEEPHOLES AT 600 mm (24 in.) O.C.
REINFORCED POLYETHYLENE FLASHING (LAP 150 mm (6 in.) TYP.)
SELF–ADHESIVE RUBBERIZED ASPHALT MEMBRANE
PRE–FINISHED METAL FLASHING TO PROJECT WATER AWAY FROM WALL
38 x 89 mm (NOMINAL 2 x 4 in.) WOOD DECKING ON WOOD JOISTS
3% SLOPE MIN.
SEALANT
BATT INSULATION IN POLYETHYLENE PILLOW, FRICTION–FIT IN PLACE (VR)
BOLTED STRUCTURAL CONNECTIONS
GALVANIZED JOIST HANGERS
SEALANT ALL AROUND JOISTS
PREFINISHED METAL WATER STOP NAILED TO JOISTS
SPUNBONDED OLEFIN AROUND HEADER
SEALANT
WEEPHOLES AT 600 mm (24 in.) O.C.
REINFORCED POLYETHYLENE FLASHING
15 lb. PERFORATED ASPHALT BUILDING PAPER (MB)
BRICK TIE NAILED INTO STUD
INTERIOR
EXTERIOR

COLUMN–SUPPORTED BALCONY WITH BRICK VENEER

SCALE: 1:5

(WALL ASSEMBLY A)

23

Detail 23: Column-Supported Balcony with Brick Veneer

COLUMN-SUPPORTED BALCONY WITH SIDING VENEER-WALL ASSEMBLY B-DETAIL 24

Notes

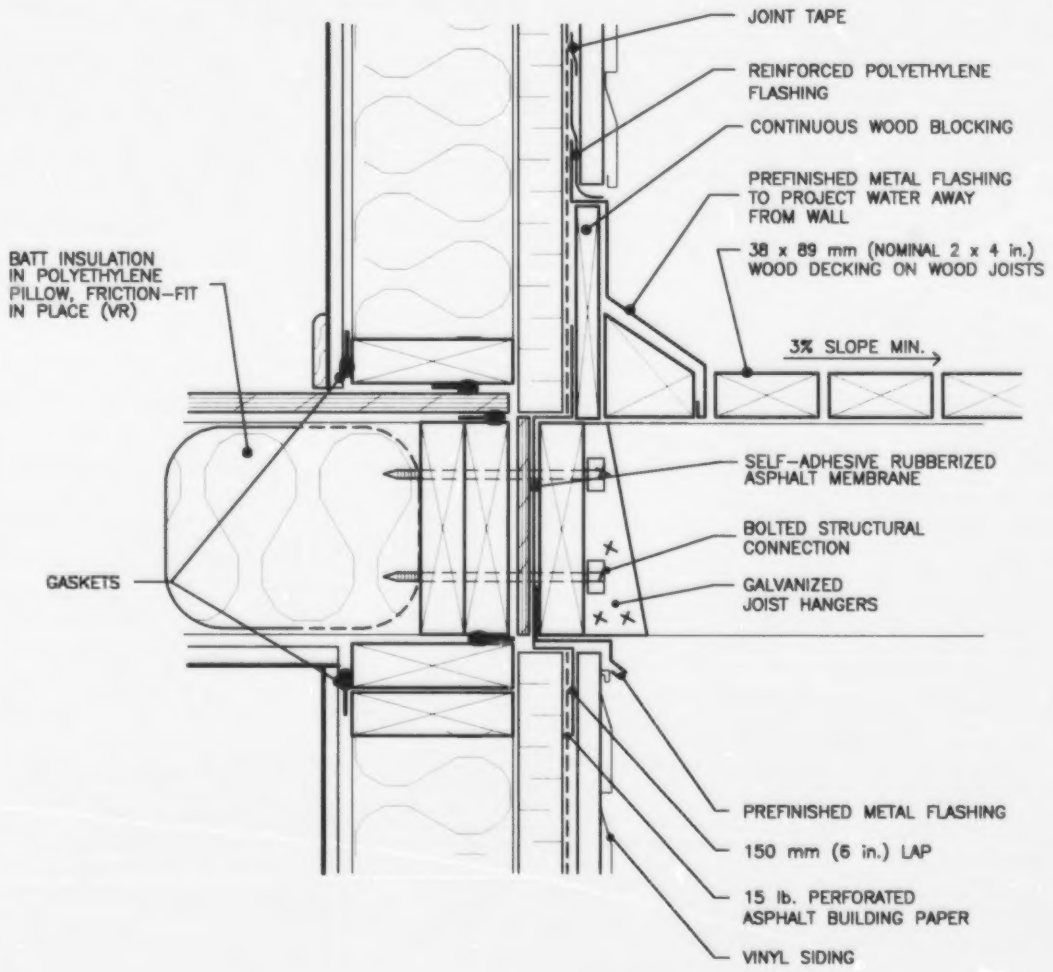
- The use of a column-supported balcony is preferable, because it results in fewer penetrations of the building envelope than a cantilevered balcony.
- The balcony floor joists are supported on a ledger bolted to the wall framing.
- At the balcony connection, a structurally rigid wall sheathing must be used in place of glass fibre sheathing.
- The wall sheathing is protected with a self-adhesive rubberized asphalt membrane before the ledger is installed.
- A flashing is installed in the siding system above the ledger and projected 100 mm (4 in.) from the wall face to direct water away from the ledger assembly.
- A flashing is installed below the ledger to direct water away from the siding assembly.
- The air-barrier system for the wall type is maintained at this location by gasketing joints in the framing.

Designer's Checklist

- Ensure that the balcony column structure will exhibit the same shrinkage characteristics as the wall structure, or allow for predicted shrinkage so that there will be drainage away from the wall.
- Locate the balcony door sill above the through-wall flashing.
- Specify pressure-treated wood for structural members and cedar or pressure-treated decking.
- Design the structural connection of the balcony to meet the load criteria.

Builder's Checklist

- Install a self-adhesive membrane before framing the balcony.
- Co-ordinate the installation of flashing and the protection membrane with the tradespeople.


JOINT TAPE
REINFORCED POLYETHYLENE FLASHING
CONTINUOUS WOOD BLOCKING
PREFINISHED METAL FLASHING TO PROJECT WATER AWAY FROM WALL
38 x 89 mm (NOMINAL 2 x 4 in.) WOOD DECKING ON WOOD JOISTS
BATT INSULATION IN POLYETHYLENE PILLOW, FRICTION–FIT IN PLACE (VR)
3% SLOPE MIN.
SELF–ADHESIVE RUBBERIZED ASPHALT MEMBRANE
BOLTED STRUCTURAL CONNECTION
GASKETS
GALVANIZED JOIST HANGERS
PREFINISHED METAL FLASHING
150 mm (6 in.) LAP
15 lb. PERFORATED ASPHALT BUILDING PAPER
VINYL SIDING
INTERIOR
EXTERIOR

COLUMN–SUPPORTED BALCONY WITH SIDING VENEER (24)
SCALE: 1:5 (WALL ASSEMBLY B)

Detail 24: Column-Supported Balcony with Siding Veneer

ATTACHED BALCONY WITH STUCCO CLADDING–WALL ASSEMBLY C–DETAIL 25

Notes

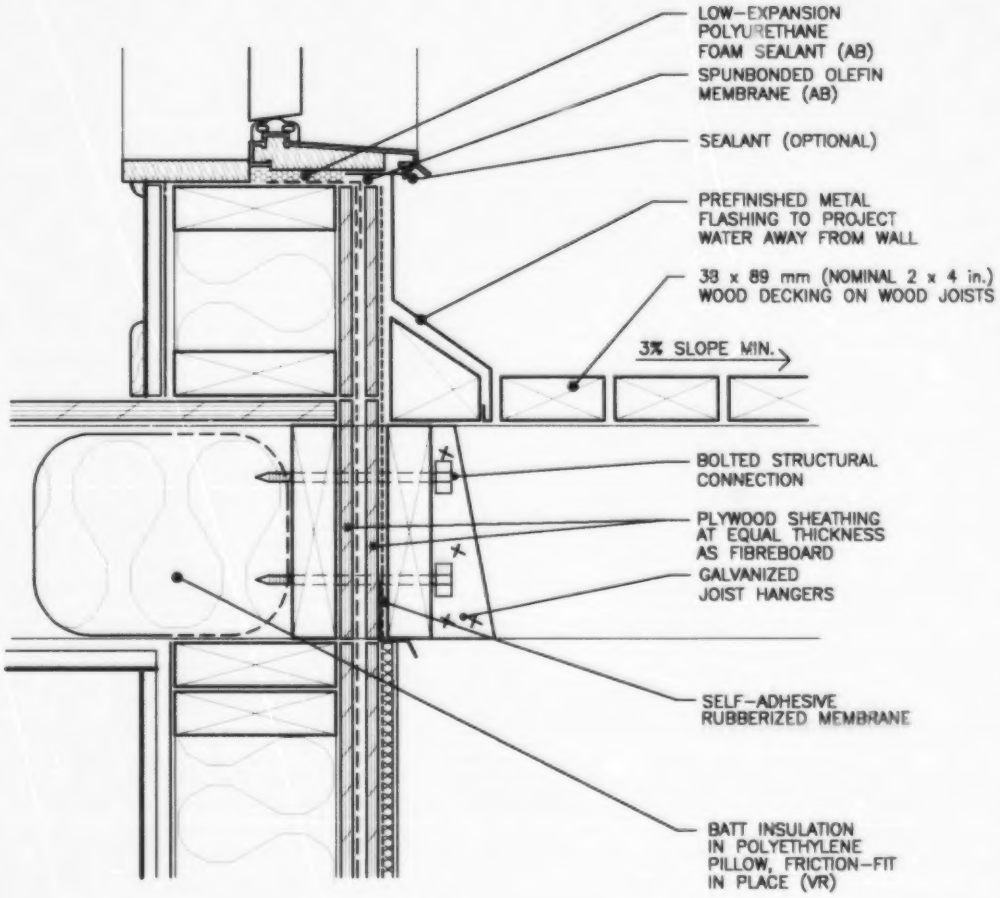
- The use of a column-supported balcony is preferable, because it results in fewer penetrations of the building envelope than a cantilevered balcony.
- The balcony floor joists are supported on a ledger bolted to the wall framing.
- At the area of balcony connection a structurally rigid wall sheathing must be used instead of fibreboard.
- The wall sheathing is protected with a self-adhesive rubberized asphalt membrane before the ledger is installed.
- A flashing is installed in the siding system above the ledger and projected 100 mm (4 in.) from the wall face to direct water away from the ledger assembly.
- A flashing is installed below the ledger to direct water away from the siding assembly.
- The air-barrier system for the wall is maintained at this location by the polyethylene and spunbonded polyolefin sandwich.

Designer's Checklist

- Ensure that the balcony column structure will exhibit the same shrinkage characteristics as the wall structure, or allow for predicted shrinkage so that there will be drainage away from the wall.
- Locate the balcony door sill above the through-wall flashing.
- Specify pressure-treated wood for structural members and cedar or pressure-treated decking.
- Design the structural connection of the balcony to meet the load criteria.
- Design the joists properly for cantilever with adequate tie-back.
- Avoid using ganged members that penetrate the wall. They are susceptible to capillary action: water will flow through the wall assembly between the joists due to differential air pressures on opposite sides of the building envelope.
- Where ganged members are absolutely necessary in the cantilevered floor structure, they must be caulked, then nailed. Instruct the builder on this point and inspect the work.
- Specify the use of western red cedar or pressure preservative-treated wood in exposed conditions.

Builder's Checklist

- Install a self-adhesive membrane before framing the balcony.
- Co-ordinate the installation of the flashing and the protection membrane with the tradespeople.
- Install sealants correctly.
- Fill the insulation cavity.


LOW–EXPANSION POLYURETHANE FOAM SEALANT (AB)
SPUNBONDED OLEFIN MEMBRANE (AB)
SEALANT (OPTIONAL)
PREFINISHED METAL FLASHING TO PROJECT WATER AWAY FROM WALL
38 x 89 mm (NOMINAL 2 x 4 in.) WOOD DECKING ON WOOD JOISTS
3% SLOPE MIN.
BOLTED STRUCTURAL CONNECTION
PLYWOOD SHEATHING AT EQUAL THICKNESS AS FIBREBOARD
GALVANIZED JOIST HANGERS
SELF–ADHESIVE RUBBERIZED MEMBRANE
BATT INSULATION IN POLYETHYLENE PILLOW, FRICTION–FIT IN PLACE (VR)
INTERIOR
EXTERIOR

ATTACHED BALCONY WITH STUCCO CLADDING
SCALE: 1:5
(WALL ASSEMBLY C)
25

Detail 25: Attached Balcony with Stucco Cladding

BALCONY OVER HEATED SPACE-WALL ASSEMBLY A-DETAIL 26

Notes

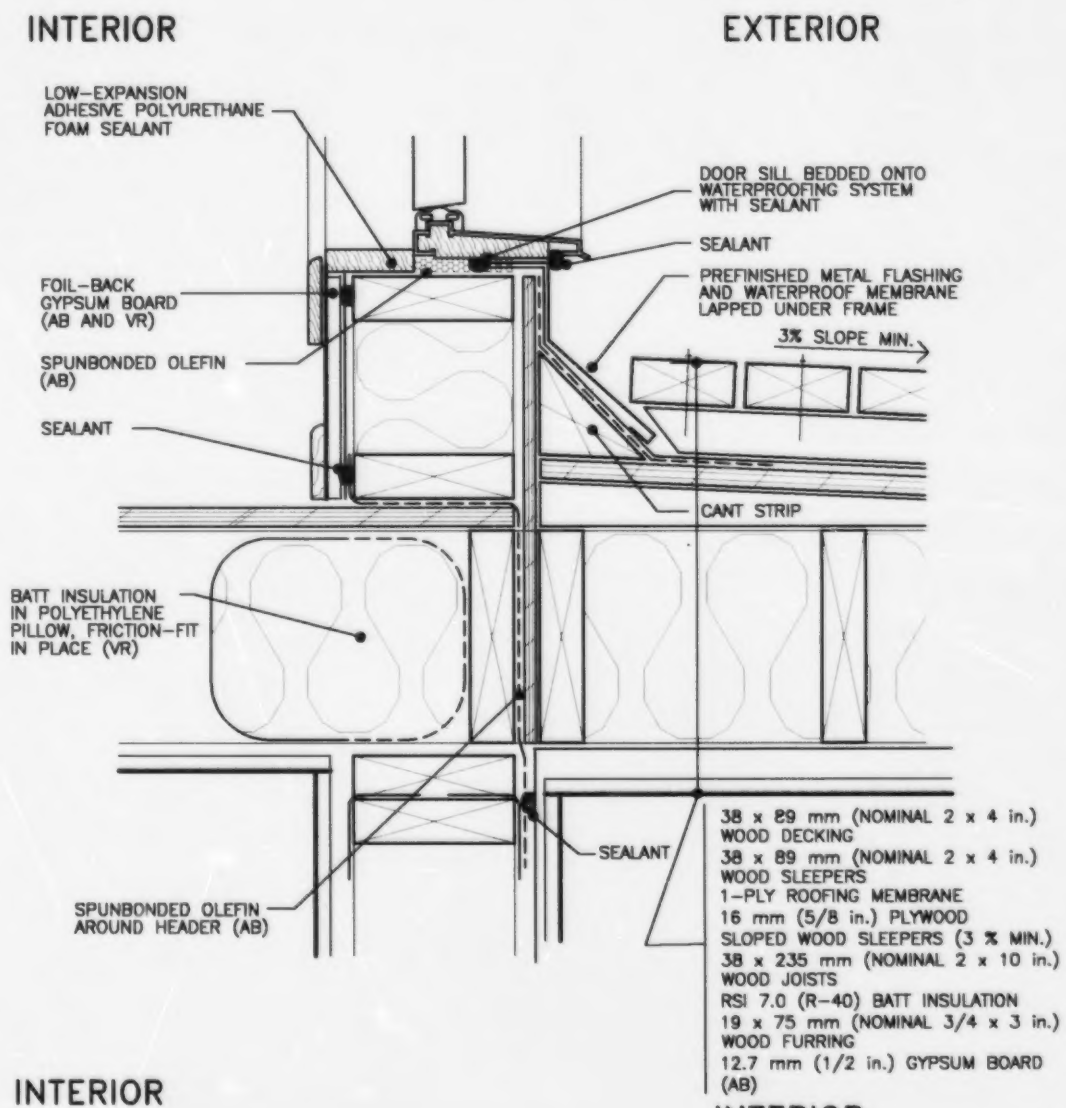
- At the second floor, the Tyvek constitutes the air barrier. The polyethylene behind the gypsum-board ceiling below the balcony also forms an air barrier. It is essential that a continuous joint be made between these two air-barrier components.
- Polyethylene sandwiched in the framing is used to link the two polyethylene air barrier components.
- At the insulated ceiling, a polyethylene sheet is used as the vapour barrier.
- Avoid penetrating the ceiling assembly if possible. Any penetrations of the polyethylene above the ceiling for lighting must be made with gasketed, airtight, electrical boxes, and wiring must be sealed at penetrations of the air barrier.
- The insulated joists are strapped to create a slope and a ventilation space.
- The sloped deck is roofed with a single-ply membrane suitable for receiving wood sleepers. This membrane must be flashed up the building face 300 mm (12 in.) or as local conditions require.
- The membrane flashing must run into the rough opening for the patio door.
- A metal flashing is placed over the membrane flashing to protect it from damage.
- The door frame is bedded in a heavy bead of sealant onto the membrane flashing.
- The junction between the metal flashing and the door sill is also caulked.

Designer's Checklist

- Review the type of air-barrier system that is being used in the wall assembly. Adapt this detail to suit the air-barrier system.
- Select a roofing membrane that is suitable for use below a wood deck.
- Where possible, locate lighting fixtures in a room below a balcony at adjacent walls instead of at the ceiling to avoid penetrating the air barrier.

Builder's Checklist

- Coordinate the framing sequence to allow for the installation of the air barrier.
- Ensure that the deck is dry and that conditions are suitable before applying a waterproofing membrane.
- Lap the waterproofing membrane flashing into the rough sill for the patio door.
- Check that the patio door is thoroughly bedded onto the membrane below it.
- Check that gasketed electrical boxes are used in the ceiling.


INTERIOR
EXTERIOR
LOW–EXPANSION ADHESIVE POLYURETHANE FOAM SEALANT
DOOR SILL BEDDED ONTO WATERPROOFING SYSTEM WITH SEALANT
SEALANT
PREFINISHED METAL FLASHING AND WATERPROOF MEMBRANE LAPPED UNDER FRAME
3% SLOPE MIN.
FOIL–BACK GYPSUM BOARD (AB AND VR)
SPUNBONDED OLEFIN (AB)
SEALANT
CANT STRIP
BATT INSULATION IN POLYETHYLENE PILLOW, FRICTION–FIT IN PLACE (VR)
SEALANT
SPUNBONDED OLEFIN AROUND HEADER (AB)
38 x 89 mm (NOMINAL 2 x 4 in.) WOOD DECKING
38 x 89 mm (NOMINAL 2 x 4 in.) WOOD SLEEPERS
1–PLY ROOFING MEMBRANE
16 mm (5/8 in.) PLYWOOD
SLOPED WOOD SLEEPERS (3 % MIN.)
38 x 235 mm (NOMINAL 2 x 10 in.) WOOD JOISTS
RSI 7.0 (R–40) BATT INSULATION
19 x 75 mm (NOMINAL 3/4 x 3 in.) WOOD FURRING
12.7 mm (1/2 in.) GYPSUM BOARD (AB)
INTERIOR
INTERIOR

BALCONY OVER HEATED SPACE

SCALE: 1:5

(WALL ASSEMBLY A)

26

Detail 26: Balcony Over Heated Space, A

BALCONY OVER HEATED SPACE-WALL ASSEMBLY B-DETAIL 27

Notes

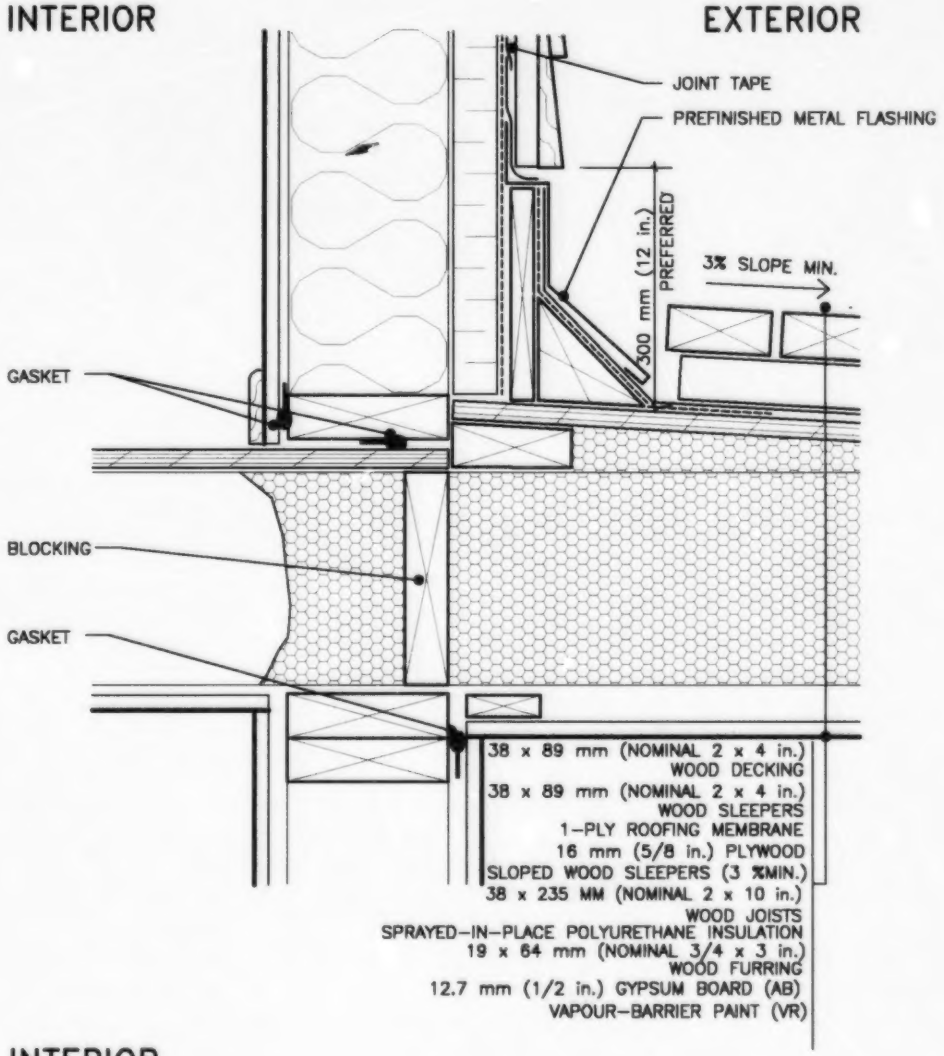
- At the second-floor exterior wall the gypsum board forms the air barrier.
- At the balcony ceiling level the air barrier is susceptible to penetration. To overcome these problems, a sprayed-in-place urethane foam is used to create an air barrier.
- The foam is an excellent material to use, because it seals to all the wood surfaces, has a high insulating value and acts as a vapour retarder.
- Refer to previous details for notes on membrane and balcony door installation.
- Due to the airtightness of this assembly, a ventilated space is not required above the insulation.
- The framing members and plywood deck must be dry before the sprayed insulation is applied.

Designer's Checklist

- Select an appropriate deck membrane for this application.
- Specify the type of spray foam application to achieve the minimum desired thermal resistance and fill all voids and cracks in and around the assembly to achieve airtightness.

Builder's Checklist

- Install the deck membrane as soon as possible after framing to protect the wood framing from the accumulation of moisture.
- Comply with the manufacturer's requirements, and ensure that the deck is dry before the membrane is applied.
- Apply foamed insulation after the membrane has been installed, and ensure framing members and deck sheathing have dried thoroughly first.


INTERIOR
EXTERIOR
JOINT TAPE
PREFINISHED METAL FLASHING
300 mm (12 in.) PREFERRED
3% SLOPE MIN.
GASKET
BLOCKING
GASKET
38 x 89 mm (NOMINAL 2 x 4 in.) WOOD DECKING
38 x 89 mm (NOMINAL 2 x 4 in.) WOOD SLEEPERS
1–PLY ROOFING MEMBRANE
16 mm (5/8 in.) PLYWOOD
SLOPED WOOD SLEEPERS (3 %MIN.)
38 x 235 MM (NOMINAL 2 x 10 in.) WOOD JOISTS
SPRAYED–IN–PLACE POLYURETHANE INSULATION
19 x 64 mm (NOMINAL 3/4 x 3 in.) WOOD FURRING
12.7 mm (1/2 in.) GYPSUM BOARD (AB)
VAPOUR–BARRIER PAINT (VR)
INTERIOR
INTERIOR

BALCONY OVER HEATED SPACE

SCALE: 1:5

(WALL ASSEMBLY B)

27

Detail 27: Balcony Over Heated Space, B

WHEELCHAIR ACCESSIBILITY

WHEELCHAIR-ACCESSIBLE BALCONY-WALL ASSEMBLY A-DETAIL 28

Notes

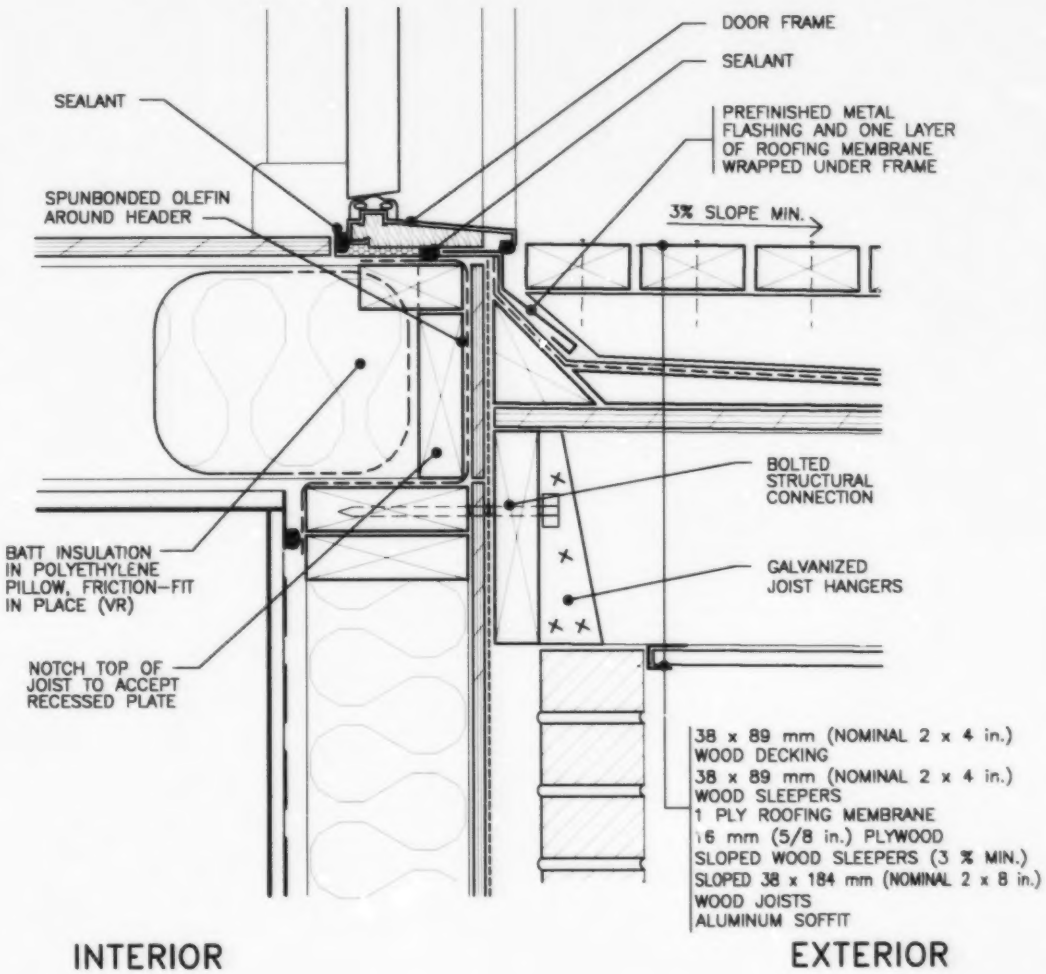
- The balcony structure is dropped below the floor level to bring the finished deck level with the door sill for wheelchair accessibility.
- Polyethylene forms the air barrier at the wall assembly. A sheathing membrane provides continuity of the air barrier at the floor level.
- The balcony framing and wall junction are protected with a roofing membrane which drains away from the building face.
- The membrane is flashed onto the patio door sub-sill, and the door frame is bedded into a heavy bead of sealant.

Designer's Checklist

- The patio door is susceptible to leakage when snow piles up against it. A roof must be provided over the balcony to minimize snow accumulation.
- Refer to previous details for discussion of the membrane and flashing.

Builder's Checklist

- Ensure that the sheathing membrane is wrapped around the headers at the appropriate stage.
- Have the membrane installed prior to the patio door.


INTERIOR
EXTERIOR
DOOR FRAME
SEALANT
SEALANT
PREFINISHED METAL FLASHING AND ONE LAYER OF ROOFING MEMBRANE WRAPPED UNDER FRAME
SPUNBONDED OLEFIN AROUND HEADER
3% SLOPE MIN.
BOLTED STRUCTURAL CONNECTION
GALVANIZED JOIST HANGERS
BATT INSULATION IN POLYETHYLENE PILLOW, FRICTION–FIT IN PLACE (VR)
NOTCH TOP OF JOIST TO ACCEPT RECESSED PLATE
38 x 89 mm (NOMINAL 2 x 4 in.) WOOD DECKING
38 x 89 mm (NOMINAL 2 x 4 in.) WOOD SLEEPERS
1 PLY ROOFING MEMBRANE
16 mm (5/8 in.) PLYWOOD
SLOPED WOOD SLEEPERS (3 % MIN.)
SLOPED 38 x 184 mm (NOMINAL 2 x 8 in.) WOOD JOISTS
ALUMINUM SOFFIT
INTERIOR
EXTERIOR

WHEELCHAIR–ACCESSIBLE BALCONY

SCALE: 1:5 (WALL ASSEMBLY A)

28

Detail 28: Wheelchair-Accessible Balcony

WHEELCHAIR-ACCESSIBLE ENTRANCE DOOR-WALL ASSEMBLY A-DETAIL 29

Notes

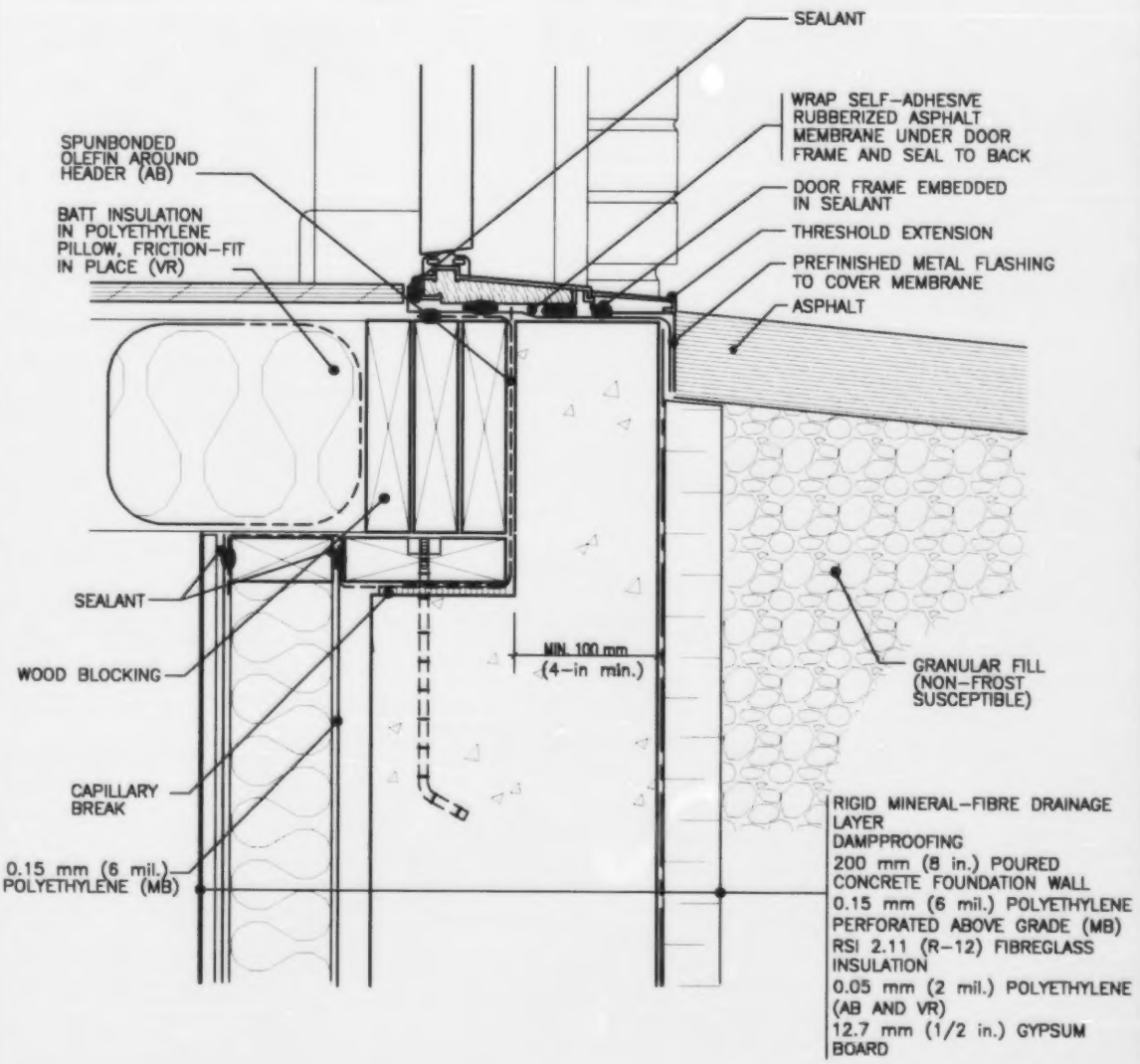
- The exterior paving is brought up level with the interior floor to allow wheelchair accessibility.
- The foundation wall is checked so that it may extend to the top of the floor framing.
- Air-barrier continuity is maintained by wrapping the floor joists with spunbonded polyolefin.
- A self-adhesive rubberized membrane is placed under the door frame and onto the face of the foundation wall. The door sill is bedded in two heavy beads of caulking onto the membrane. This prevents standing water or snow seeping under the door sill and into the building interior.
- The rubberized membrane is turned upward at the interior side of the door and at each end of the door opening.
- Non-frost-susceptible granular fill is used below the paving to the full depth of possible frost penetration. This prevents lifting of the paving and the possible reversing of the flow of water towards the door.
- Paving is sloped away from the door (at least two per cent) to prevent ponding and water infiltration. (Slopes over five per cent must be designed as ramps.)

Designer's Checklist

- Provide a roof canopy over the entrance to protect it from snow accumulation.
- Specify a rubberized membrane with appropriate primers for use over the concrete.
- Clearly specify the thickness and height of the foundation wall to create upstand.
- Specify the extended door threshold.

Builder's Checklist

- Verify that correctly dimensioned blocking is built into concrete formwork to provide a check for the wall above.
- Co-ordinate the installation of the membrane with the framing work.
- Verify the actual height of the door sill to ensure that the level of the finished floor correctly aligns with the threshold for wheelchair accessibility.
- Ensure insulation is mechanically attached to the foundation to prevent frost heave from lifting it out of the ground.


SEALANT
WRAP SELF–ADHESIVE RUBBERIZED ASPHALT MEMBRANE UNDER DOOR FRAME AND SEAL TO BACK
DOOR FRAME EMBEDDED IN SEALANT
THRESHOLD EXTENSION
PREFINISHED METAL FLASHING TO COVER MEMBRANE
ASPHALT
SPUNBONDED OLEFIN AROUND HEADER (AB)
BATT INSULATION IN POLYETHYLENE PILLOW, FRICTION–FIT IN PLACE (VR)
SEALANT
WOOD BLOCKING
CAPILLARY BREAK
0.15 mm (6 mil.) POLYETHYLENE (MB)
MIN. 100 mm (4–in min.)
GRANULAR FILL (NON–FROST SUSCEPTIBLE)
RIGID MINERAL–FIBRE DRAINAGE LAYER
DAMPPROOFING
200 mm (8 in.) POURED CONCRETE FOUNDATION WALL
0.15 mm (6 mil.) POLYETHYLENE PERFORATED ABOVE GRADE (MB)
RSI 2.11 (R–12) FIBREGLASS INSULATION
0.05 mm (2 mil.) POLYETHYLENE (AB AND VR)
12.7 mm (1/2 in.) GYPSUM BOARD

WHEELCHAIR–ACCESSIBLE ENTRANCE DOOR

SCALE: 1:5

(WALL ASSEMBLY A)

29

Detail 29: Wheelchair-Accessible Entrance Door

PARTY WALLS AND FIRE WALLS

PARTY WALL–WALL ASSEMBLY A–DETAIL 30

Where party walls are constructed as gypsum-board and wood frame assemblies, they may generally be treated like other partitions. Where masonry is used, the detailing becomes important to ensure that air-barrier continuity and thermal performance are achieved.

Notes

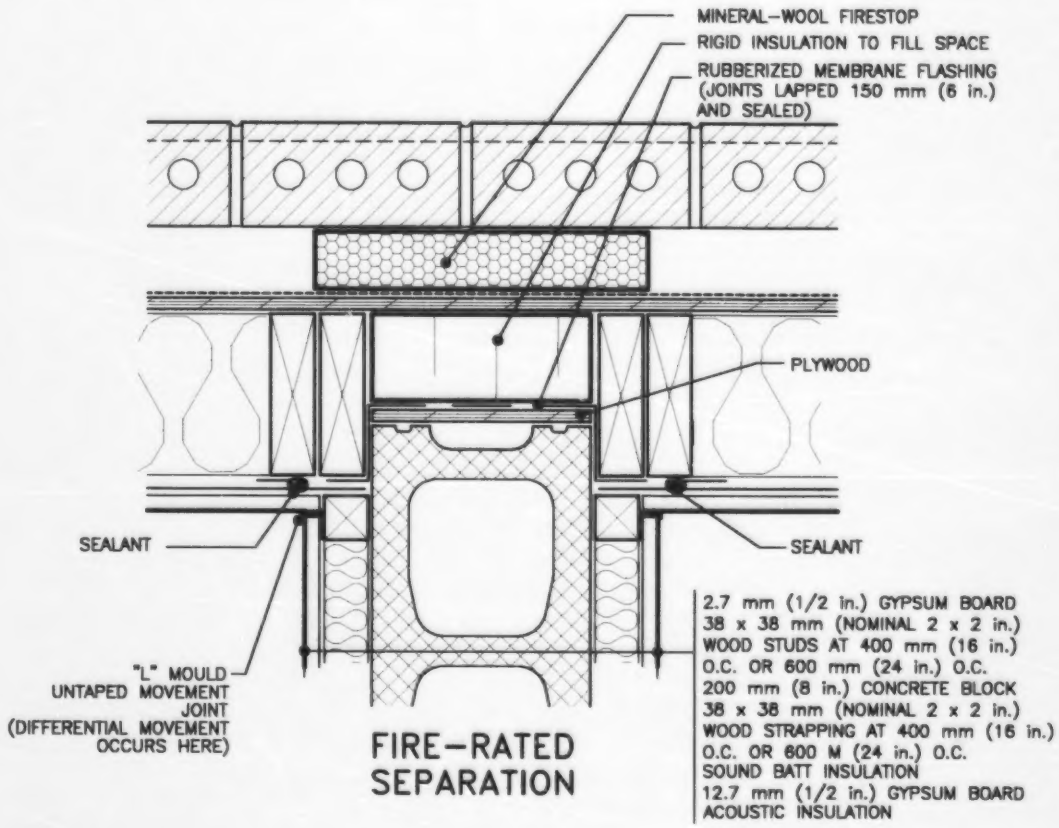
- An EASE system (Wall System C) may run past the end of a party wall.
- An ADA must be extended around the end of the party wall. Concrete block is very porous and is not an airtight material.
- A rubber membrane is sandwiched between plywood and rigid insulation to continue the air-barrier system around the block.
- The wood framing is expected to shrink in height relative to the concrete-block structure.
- If drywall is secured to strapping on the block wall, a movement joint must be provided between the party wall and the exterior wood frame-wall gypsum board.
- If the gypsum-board finish at the party wall is installed on an independent wood stud wall and not secured to masonry back up, a movement joint is not required.
- If the masonry party wall extends above the upper ceiling level, a similar detail incorporating an air barrier must be used at attic level to ensure continuity of the air-barrier system between dwelling units (see Detail 32).
- Firestopping is provided in the brick veneer cavity at all locations of fire separations.

Designer's Checklist

- Determine which air-barrier system is being used in the exterior assembly, and adjust the detail accordingly.
- Determine the amount of cumulative shrinkage expected in the wood framing due to drying of the wood.
- Specify S-Dry lumber to minimize shrinkage.
- Specify a movement joint when required.
- Specify a firestop material where there is a wall cavity.

Builder's Checklist

- Co-ordinate the installation of the air barrier between framing and masonry work.
- Ensure that the movement joint is constructed correctly.
- Verify that firestop material is being placed at fire separations in the veneer cavity.


MINERAL–WOOL FIRESTOP
RIGID INSULATION TO FILL SPACE
RUBBERIZED MEMBRANE FLASHING (JOINTS LAPPED 150 mm (6 in.) AND SEALED)
PLYWOOD
SEALANT
SEALANT
"L" MOULD UNTAPED MOVEMENT JOINT (DIFFERENTIAL MOVEMENT OCCURS HERE)
2.7 mm (1/2 in.) GYPSUM BOARD
38 x 38 mm (NOMINAL 2 x 2 in.) WOOD STUDS AT 400 mm (16 in.) O.C. OR 600 mm (24 in.) O.C.
200 mm (8 in.) CONCRETE BLOCK
38 x 38 mm (NOMINAL 2 x 2 in.) WOOD STRAPPING AT 400 mm (16 in.) O.C. OR 600 M (24 in.) O.C.
SOUND BATT INSULATION
12.7 mm (1/2 in.) GYPSUM BOARD
ACOUSTIC INSULATION
FIRE–RATED SEPARATION

NOTE:
ALL MATERIALS TO CONFORM TO NBC

PARTY WALL, HORIZONTAL SECTION

SCALE: 1:5 (WALL ASSEMBLY A)

30

Detail 30: Party Wall, Horizontal Section

FIRE WALLS–WALL ASSEMBLY A–DETAILS 31 AND 32

Notes

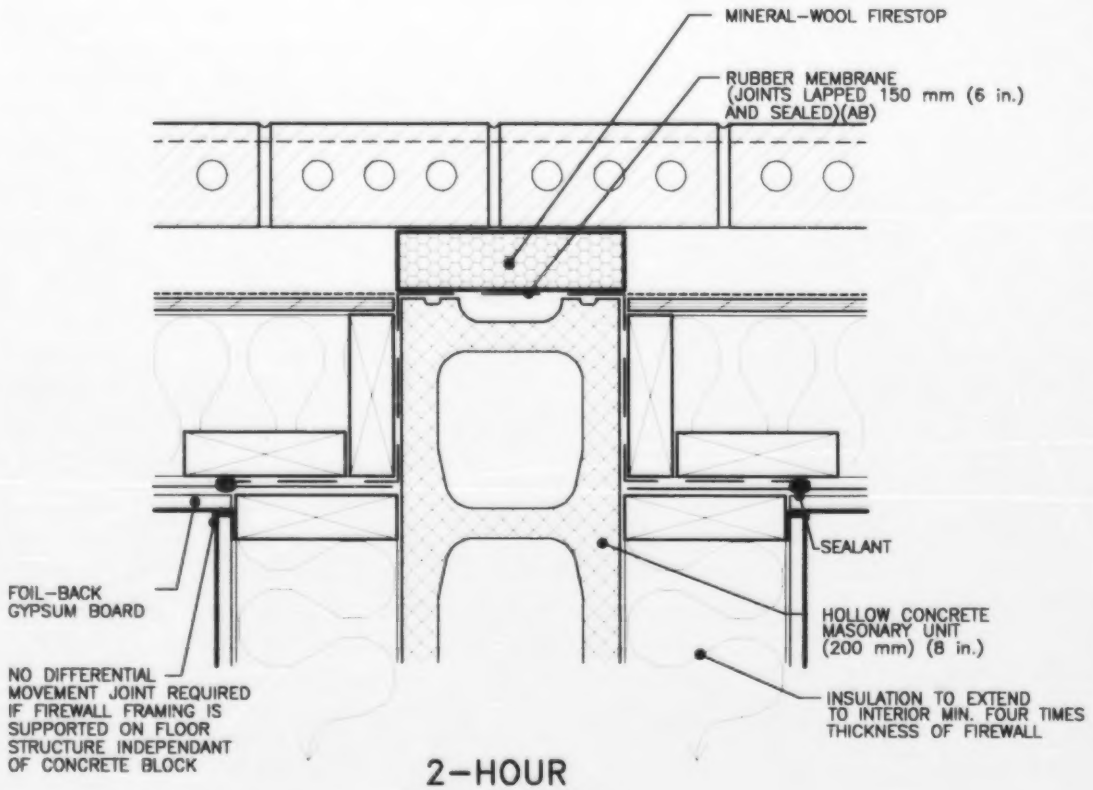
- No combustible material may extend across the end of the firewall.
- Thermal bridging is reduced by extending insulation back from the exterior wall to a distance of four times the wall thickness.
- A rubber membrane is extended around the end of the firewall to link the gypsum-board air-barrier elements in the walls. (Where the wall sheathing is the air-barrier element, the membrane must link the sheathing.)
- At the attic level, extend the rubber membrane through the blockwork to link the gypsum-board air-barrier elements.
- (The designer may also consider an alternate approach to air barrier integration by treating the firewall as being outside the building envelope. The exterior wall insulation and air-barrier system are then carried the full height and width of the demising wall (party wall separation) on both sides of the firewall construction. Penetrations of the firewall must then be treated as penetrations of the exterior envelope.)

Designer's Checklist

- Consider the size and configuration of the building, and determine whether the fire wall should be within the building envelope or outside of it.
- Determine which air-barrier system is being used in the building envelope.
- Determine the amount of cumulative shrinkage expected in the wood structure due to drying of the wood. Specify S-Dry lumber to minimize shrinkage.
- Specify the appropriate rubberized membrane and sealant.
- Include movement joints in details where required.
- Ensure gaskets on acoustic sealant are placed to eliminate the transfer of flanking noise at ceilings, floors and walls.

Builder's Checklist

- Co-ordinate the installation of rubberized membrane and seals with the tradespeople.
- Ensure that movement joints are constructed as shown.


MINERAL–WOOL FIRESTOP
RUBBER MEMBRANE (JOINTS LAPPED 150 mm (6 in.) AND SEALED)(AB)
SEALANT
FOIL–BACK GYPSUM BOARD
HOLLOW CONCRETE MASONARY UNIT (200 mm) (8 in.)
NO DIFFERENTIAL MOVEMENT JOINT REQUIRED IF FIREWALL FRAMING IS SUPPORTED ON FLOOR STRUCTURE INDEPENDANT OF CONCRETE BLOCK
INSULATION TO EXTEND TO INTERIOR MIN. FOUR TIMES THICKNESS OF FIREWALL

2–HOUR
FIRE–RATED
SEPARATION

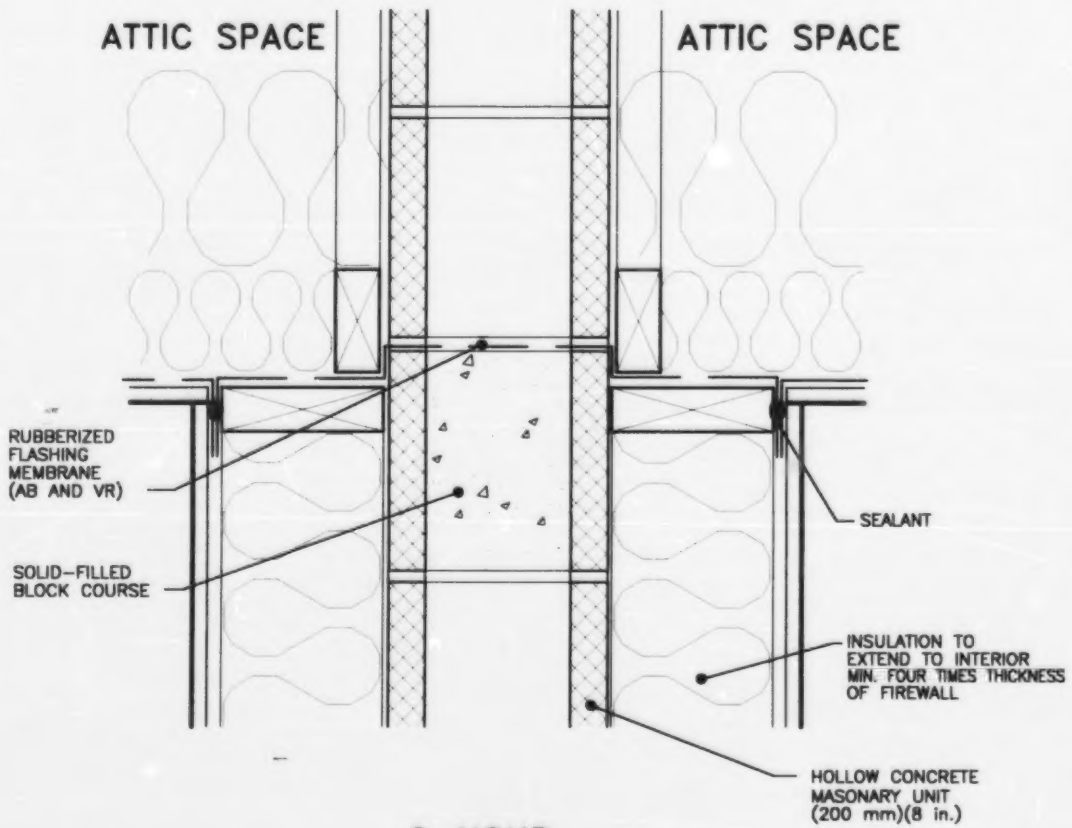
NOTE:
ALL MATERIALS TO CONFORM TO NBC

FIRE WALL, HORIZONTAL SECTION

SCALE: 1:5 (WALL ASSEMBLY A)

31

Detail 31: Fire Wall, Horizontal Section


ATTIC SPACE
ATTIC SPACE
RUBBERIZED FLASHING MEMBRANE (AB AND VR)
SOLID-FILLED BLOCK COURSE
SEALANT
INSULATION TO EXTEND TO INTERIOR MIN. FOUR TIMES THICKNESS OF FIREWALL
HOLLOW CONCRETE MASONARY UNIT (200 mm)(8 in.)

2-HOUR FIRE-RATED SEPARATION

NOTE:
ALL MATERIALS TO CONFORM TO NBC

FIRE WALL
SCALE: 1:5

(WALL ASSEMBLY A)

32

Detail 32: Fire Wall

CHAPTER 8

SPECIFICATIONS

The following specification sections are intended to be read in conjunction with the details illustrated in Chapter 7.

Where the details show alternative materials, specifications are provided for the various options. Neither the details nor the specifications purport to illustrate the only materials available in the construction of wood frame building envelopes. Specifiers and designers should verify the availability of products in their locale.

Rough Carpentry (Section 06100)

Kiln-dried, S-Dry wood is specified. If this material is not available, the air-barrier system and sheathing material should be selected accordingly. See Chapter 4.

This section includes all of the sheathing products used in the various wall assemblies:

- plywood and OSB
- rigid fibreglass panels
- laminated fibreboard
- asphalt-impregnated fibreboard

Only those used should be specified.

Prefabricated Wood Trusses (Section 06192)

Use S-Dry wood, if feasible, to minimize the potential for truss uplift.

Verify the cost and availability of S-Dry lumber before you specify it.

Insulation (Section 07200)

The specifier should determine which types of vapour diffusion retarder and insulation are to be used.

The polyethylene vapour retarder need be sealed in the illustrated assemblies only where the polyethylene acts as an air-barrier element. When the polyethylene acts as a vapour retarder only, it is specified as .05 mm (2 mil.).

Sealants, Gaskets and Air-Barrier Membranes (Section 07900)

Sealants and gaskets selected should be those intended for use with the chosen air barrier system. (See the notes in Chapter 7.)

Gypsum Wallboard (Section 09250)

This specification section is intended for use where the Airtight Drywall Approach (ADA) to air barriers is used.

Wall Assembly A uses polyethylene and sealants in the air-barrier assembly. These products and procedures should be selected for specifications used with this system (see points 2.1.2 and 3.3).

When Wall Assembly B is being used, the specifier should select regular gypsum board and gasket installation procedures (see point 3.2).

Such membrane products as spunbonded polyolefin or polyethylene are included within the sections that deal with their installation. For example, polyethylene is included in Section 09250, "Gypsum Wallboard," and spunbonded polyolefin can be found in Section 06100, "Rough Carpentry."

CMHC Best Practice Guide Wood Frame Envelopes	ROUGH CARPENTRY	Section 06100 Page 1 of 4

PART 1–GENERAL

1.1	Related Work Specified Elsewhere	.1	Setting of Anchor Bolts–Section 03100 (not included in this guide)
		.2	Prefabricated Wood Trusses–Section 06192
		.3	Finish Carpentry–Section 06200 (not included in this guide)
		.4	Insulation–Section 07200
		.5	Sealants, Gaskets and Air-Barrier Membranes–Section 07900
1.2	Canadian Source Quality Control	.1	Identify lumber by the grade stamp of an agency certified by the Canadian Lumber Standards Accreditation Board.
1.3	Reference Standards	.1	Comply with the NBC or the latest edition as a minimum standard.

PART 2–PRODUCTS

2.1	Lumber Material	.1	Lumber shall be softwood, S4S, S-Dry, kiln-dried, with a moisture content not greater than 19 per cent at the time of installation, in accordance with CSA 0141.
		.2	Framing Lumber: All framing shall be No. 2 grade and better Spruce-Pine-Fir.
		.3	Furring and Blocking: No. 2 grade and better Spruce-Pine-Fir.
		.4	Pressure-treated wood: No. 1 grade pine treated in accordance with CAN/CSA 080 series 97.
2.2	Panel Material	.1	Panels for sheathing shall conform to the following standards: Construction Sheathing CAN/CSA-0325.0-92 Waferboard or Strandboard CAN/CSA 0437 series 93, or CAN/CSA 0121, or CAN/CSA 0151 Douglas Fir Plywood CAN/CSA 0121-M1978 Canadian Softwood Plywood CAN/CSA 0151-M1978 Insulating Fibreboard CAN/CSA A247-M86 (reaffirmed in 1996).

.2 Wall Sheathing: Oriented strandboard (OSB) 11 mm (5/16 in.) thick, or Douglas fir plywood or Canadian softwood plywood.

.3 Wall Sheathing: Insulating asphalt-impregnated fibreboard, 11 mm (7/16 in.) thick.

.4 Floor Sheathing: Waferboard or OSB 15.9 mm (5/8 in.) thick tongue-and-groove edging.

.5 Floor Sheathing: Softwood plywood, 15.9 mm (5/8 in.) thick, sheathing grade or as shown, tongue-and-groove edging.

.6 Floor sheathing forming part of a fire-rated floor assembly: Phenolic bonded Douglas fir plywood, 20 mm (3/4 in.) thick or as shown, tongue-and-groove edging.

.7 Roof Sheathing: Plywood, 12.7 mm (1/2 in.) thick.

.8 Roof Sheathing: OSB, 12.7 mm (1/2 in.) thick.

.9 Flooring Underlay: 6-mm (1/4-in.) G1S. poplar plywood that complies with CSA 0153-M1980 standards.

.10 Glass fibre sheathing board: spunbonded olefin faced mineral fibre, Type 2, that conforms to CAN2-51.32-M Sheathing, Membrane, Breather Type standards.

2.3 Building Papers .1 Exterior Wall Sheathing Paper: complies with CGSB-51.32-M77 breather type standards. (Spec note: These materials are not considered air barriers but can be used as moisture barriers. Spunbonded olefin can be considered as part of an air-barrier system when used as specified elsewhere.)

a) Perforated asphalt-impregnated felt
b) Spunbonded olefin

2.4 Fastenings and Hardware .1 Fastenings and hardware in accordance with the NBC and CSA B111-1974, Wire Nails, Spikes and Staples, Subsection 9.2.3.3.

.1 For framing, wall and roof sheathing use spiral nails.

.2 For floor sheathing and underlayment, use screws.

.3 For fencing, decking and exterior work, use galvanized spiral nails.

.2 Bolt, nut, washer, screw and pin type fasteners with hot-dip galvanized finish for exterior work.

.3 Joist Hangers: minimum 1-mm (0.039-in.)-thick sheet steel, galvanized, 6672-N bearing strength.

.4 Roof Sheathing H-Clips: formed "H" shape, thickness to suit panel material.

.5 Use nailing discs as recommended by manufacturer for glass fibre sheathing.

2.5 Sheathing Tape .1 Contractors' sheathing tape: approved by membrane manufacturer for sealing joints in spunbonded olefin-faced fibreglass sheathing, sheathing membrane and membrane-faced fibreboard.

2.6 Construction Adhesive .1 Subfloor adhesive: conforms to CAN/ CGSB 71.26-88M, Field-Gluing Plywood to Lumber Framing for Floor Systems standards, cartridge-loaded.

PART 3–EXECUTION

3.1 Wood Frame Construction .1 Comply with all the requirements of the NBC, Section 9.23, Wood Frame Construction.

3.2 Erection of Framing Members and Panel Material .1 Install members and panels to plumb line, levels and elevations.

.2 Construct continuous members from pieces of the longest practical length.

.3 Install spanning members with "crown edge" up.

.4 Install H-clips at all unsupported joints of roof sheathing, installing clips at mid-points of the spans.

3.3	Furring, Blocking, Cutting, Framing and Accommodation of Other Work	.1	Do all cutting, framing, blocking, furring and fitting work for the passage of pipes, ducts, conduits, mechanical and electrical equipment, including back-up boards for electrical panels.
		.2	Provide solid blocking for support of handrails, cabinets, hardware grab bars and plumbing fixtures.
		.3	Co-ordinate this work with other trades to ensure the correct installation of all items.
		.4	Provide 38-mm (1 1/2-in.)-thick lumber fire stops at all floor and ceiling levels and alongside stair stringers so that stud spaces are discontinuous.
3.4	Caulking and Gaskets	.1.	Install caulking and gaskets as specified elsewhere and as shown.
3.5	Building Paper	.1	Install sheathing paper horizontally over wall sheathing, lapping edges 100 mm (4 in.).
3.6	Sheathing Membrane	.1	Install sheathing membrane in accordance with the manufacturer's instructions and as shown.
		.2	Seal all joints with tape.
3.7	Subfloor Installation	.1	Adhere sheathing to floor joists where indicated.
		.2	Apply a continuous bead in accordance with the manufacturer's recommendations to the ribbon joist and floor joists.

CMHC Best Practice Guide Wood Frame Envelopes	PREFABRICATED WOOD TRUSSES	Section 06192 Page 1 of 3

PART 1–GENERAL

1.1	Related Work Specified Elsewhere	.1	Rough Carpentry–Section 06100
1.2	Reference	.1	Do fabrication of wood trusses in accordance with *Standards* CAN/CSA-086.1-94, except where otherwise specified.
1.3	Design Criteria	.1	Design roof trusses in accordance with CAN/CSA-086.1-94, Engineering Design in Wood (Limit States Design), to safely carry snow and drift loads for building locality as ascertained by *NBC Supplement No. 1, Climatic Information for Building Design in Canada*. (Drawings shall bear the stamp of a registered professional engineer.)
		.2	Where gypsum-board ceilings are hung directly from trusses, limit live load deflection to 1/360th of span. Allow for the temporary weight of attached partitions below.
1.4	Source Quality Control	.1	Identify lumber by the grade stamp of an agency certified by the Canadian Lumber Standards Accreditation Board.
1.5	Shop Drawings	.1	Submit shop drawings in accordance with Section 01100 (not included in this guide).
		.2	Each shop drawing submitted shall bear the stamp of a qualified professional engineer registered in Canada.
		.3	Indicate species, sizes and stress grades of lumber used as truss members. Show pitch, span, camber configuration and spacing of trusses. Indicate connector types, thicknesses, sizes, locations and design value. Show bearing details.
1.6	Delivery and the Manufacturer's Storage Instructions	.1	Store trusses on job site in accordance with the manufacturer's instructions. Provide bearing supports and bracings to prevent bending or overturning of trusses during transit and storage.

PART 2–PRODUCTS

2.1 Materials

.1 Lumber: S-Dry S4S, with maximum moisture content of 19 per cent at time of fabrication and in accordance with the following standards:

- .1 CSA 0141-91 Softwood Lumber
- .2 NLGA Standard Grading Rules for Canadian Lumber, 1996.
- .3 Fastenings should conform to CAN/CSA-086.1-94 standards.
- .4 Truss plates should conform to Truss Plate Institute standards.

2.2 Fabrication

.1 Fabricate wood trusses in accordance with reviewed shop drawings.

.2 Cut truss members to accurate length, angle and size to assure tight joints for finished trusses.

.3 Assemble truss members in the design configuration by securing them tightly in jigs or with clamps.

.4 Provide for design camber when positioning truss members.

.5 Connect members using metal plates.

PART 3–EXECUTION

3.1 Erection

.1 Use lifting points, as indicated, to hoist trusses into position.

.2 Exercise care to prevent out-of-plane bending of trusses.

.3 Install temporary horizontal and cross bracing to hold trusses plumb and in safe condition until permanent bracing is installed.

.4 Install permanent bracing and related components before applying loads to trusses.

.5 Trusses with loose connector plates are not acceptable.

.6 Restrict construction loads to prevent overstressing of truss members.

.7 Do not cut or remove any truss material.

PART 1–GENERAL

1.1 Related Work Specified Elsewhere

.1 Rough Carpentry–Section 06100

.2 Subgrade Insulation–Section 07212

.3 Sealants, Gaskets and Air-Barrier Membranes–Section 07900

1.2 Handling and Storage of Materials

.1 Store packaged materials in original undamaged containers with manufacturer's labels and sealsintact. Deliver to site in sealed packages.

.2 Prevent damage to materials during handling, storing and erection. Damaged materials will be rejected.

PART 2–PRODUCTS

2.1 Installation Material

.1 Batt insulation shall be unfaced friction-fit fibrous glass wool insulation and shall conform to CAN/ULC-S702-97 Mineral Fibre Thermal Insulation for Buildings, Type 1A standards.

.2 Batt insulation shall be mineral wool insulation and shall conform to the standards set out in CAN/ULC-S702-97 Mineral Fibre Thermal Insulation for Buildings, Type 1.

.3 Sprayed-in-place cellulose fibre wall insulation shall conform to CAN/ULC-S703 Cellulose Fibre Loose Fill Thermal Insulation C (previously CAN/CGSB-51.60-M90), complete with jute mesh backing as supplied by the manufacturer.

.4 Attic insulation shall be blown-in fibreglass insulation conforming to the standards set out in CAN/ULC-S702-97 Mineral Fibre Thermal Insulation for Buildings and installed in accordance with CGSB 51-GP-45MP Manual for Installers of Mineral Fibre Blown Loose Fill Thermal Insulation.

.5 Attic insulation shall be blown-in cellulose fibre insulation conforming to the standards set out in CAN/CGSB 51-GP-44MP Manual for Installers of Cellulose Fiber Thermal Insulation.

.6 Polyurethane foam insulation conforming to the standards set out in CAN/ULC-705.1 Thermal Insulation-Spray Applied Rigid Polyurethane Foam, Medium Density, Material–Specification Class 1. Installed to the standards of CAN/ULC-S705.2 Installer's Responsibilities–Specification.

.7 Vapour retarder, when not employed also as an air-barrier material, shall be a .05-mm (2-mil.)-thick polyethylene sheet conforming to CAN/CGSB-51.34-M86, Vapour Barrier, Polyethylene Sheet for Use in Building Construction.

PART 3–EXECUTION

3.1 Polyethylene Vapour Retarder

.1 Unless otherwise indicated, apply polyethylene to the warm side of exterior walls and ceilings using wide pieces to result in the fewest joints possible.

.2 Make joints over solid bearing and lap 50 mm (2 in.). Do not seal. Staple in position at not more than 200 mm (8 in.) o.c. on all edges and as required to assist installation.

.3 Repair damaged or torn membrane with pressure-sensitive tape recommended for the purpose by the tape manufacturer, unless in the opinion of the architect, damage is too great to be repaired, in which case, a new undamaged membrane must be provided.

.4 At all openings in the exterior walls, such as windows and doors, the polyethylene shall be cut neatly around the opening and fastened against the frame of the opening or as shown.

.5 Where pipe duct shafts are located against exterior walls, install polyethylene and drywall continuously prior to enclosing the shafts.

.6 Polyethylene at ceilings shall be installed with all joints lapped by 100 mm (4 in.) and all joints occurring at framing members.

.7 Extend the ceiling vapour barrier over the top of all interior partitions.

3.2	Batt Wall Insulation	.1	Install insulation to maintain continuity of the thermal protection to the building elements and spaces.
		.2	Fit the insulation tight to electrical boxes, plumbing and heating pipes and ducts, and around external doors and windows and protrusions.
		.3	Cut and trim insulation neatly to fit spaces. Use insulation free of ripped edges. Fill all voids.
3.3	Foam Sealant Installation	.1	Install polyurethane foam sealant at the perimeter of windows, doors and other exterior wall penetrations between the unit and the rough frame in accordance with the manufacturer's instructions.
		.2	Ensure continuity of installation against air leakage.
		.3	Ensure that window frames, door frames or other items are not damaged or distorted by foam.
		.4	Trim neatly, flush with frame.
3.4	Sprayed-in-Place Cellulose Wall Insulation	.1	Mechanically fasten mesh to wall studs with staples.
		.2	Cut holes in the mesh where required for insertion of a pneumatic insulation delivery tube.
		.3	Pneumatically place insulation in the walls successively between studding to provide minimum specified thermal resistance value.
		.4	Keep insulation a minimum of 75 mm (3 in.) from heat-emitting devices such as recessed light fixtures, and a minimum 50 mm (2 in.) from sidewalls of Type A chimneys, according to CAN/ULC-S604-M91 Standard for Factory Built Type A Chimneys, and for Types B and L vents according to CAN/ULC-B149.1 Natural Gas Installation Code and CAN/ULC-149.2 Propane Installation Code.

.5 Remove insulation material spilled during installation, and leave work ready for the application of wallboard.

3.5 Attic Insulation

.1 Install blown-in attic insulation to applicable standard.

.2 Install preformed vent channels at all truss spaces above the exterior wall.

.3 Ensure that insulation is not placed on ventilated soffits.

.4 Use batt insulation for all sloped ceilings.

.5 Insulate and weatherstrip the attic hatch.

CMHC Best Practice Guide Wood Frame Envelopes	SUBGRADE INSULATION	Section 07212 Page 1 of 1

PART 1–GENERAL

1.1	Related Work Specified Elsewhere	.1	Insulation–Section 07200
1.2	Handling and Storage of Materials	.1	Store packaged materials in original undamaged containers with the manufacturer's labels and seals intact. Deliver to the site in sealed packages.
		.2	Store packaged materials and manufactured items off the ground, and cover with weatherproof covering.
		.3	Do not leave polystyrene insulation exposed to sunlight. Cover polystyrene insulation with light-coloured tarpaulins at all times.
1.3	Preparations	.1	Surfaces to receive insulation shall be level.

PART 2–PRODUCTS

2.1	Materials	.1	Extruded polystyrene conforming to the standards set out in CAN/ULC-S701-97 Type 3, Thermal Insulation, Polystyrene, Boards and Pipe Covering.
		.2	Rigid mineral fibre conforming to the standards set out in CAN/ULC-S702-97 Mineral Fibre Thermal Insulation for Buildings.

PART 3–EXECUTION

3.1	Installation	.1	Install insulation as shown on the drawings.
		.2	Butt the insulation boards tightly together.
		.3	Ensure that the insulation is not displaced during backfilling and slab-pouring operations.

CMHC Best Practice Guide Wood Frame Envelopes	SEALANTS, GASKETS AND AIR BARRIER MEMBRANES	Section 07900 Page 1 of 4

PART 1–GENERAL

1.1	Related Work Specified Elsewhere	.1	Insulation–Section 07200
		.2	Gypsum Wallboard–Section 09250
1.2	Delivery, Storage and Handling	.1	Deliver and store materials in original wrappings and containers with the manufacturer's seals and labels intact. Protect sealants from freezing, moisture and water.
1.3	Environmental and Safety Requirements	.1	Comply with the requirements of the Workplace Hazardous Materials and Safety Information System (WHMIS) regarding the use, handling, storage and disposal of hazardous materials and regarding labelling and the provision of material safety data sheets acceptable to Labour Canada.
		.2	Conform to the manufacturer's recommended temperatures, relative humidity and substrate moisture content for the application and curing of sealants, including special conditions governing use.
1.4	Guarantee	1.	Provide a written guarantee, signed and issued in the name of the owner, stating that caulking work of this section is guaranteed against leakage, cracking, crumbling, melting, shrinkage, running, loss of adhesion, staining adjacent surfaces or other failure, for a period of three years from the date of Certificate of Substantial Performance.

PART 2–PRODUCTS

2.1	Sealants	.1	Cladding Joint Sealant: One-component acrylic base, solvent curing compound that conforms to the standards set out in CAN/CGSB 19GP-5M.
		.2	Cladding Movement Joint Sealant: One-component elastomeric (urethane) chemical curing compound that conforms to the standards set out in CAN/CGSB 19.13-M87.

.3 Interior Air-Barrier Element Sealant: One-component elastomeric (urethane) chemical curing compound that conforms to the standards set out in CAN/CGSB 19.13-M87 (not for use on polyethylene).

.4 Glazing Tape: 100 per cent solid, cross-linked butyl preformed sealant (non-shimmed).

2.2 Sealant Accessories

.1 Primer, where required, shall be as recommended by the sealant manufacturer.

.2 Back-up Materials: polyethylene, urethane, neoprene or vinyl foam

.1 Extruded closed-cell foam backer rod.

.2 Size: oversize 30 to 50 per cent

.3 Bond breakers, where required, shall be polyethylene tape which will not bond to sealant.

.4 Cleaning solvent shall be coal tar naphtha equal to "Xylol" or as recommended by the sealant manufacturer.

2.3 Gaskets

.1 Sill Gasket: Closed-cell polyethylene strip gasket sized to suit plate.

.2 Air Barrier Component Gasket: Closed-cell polyvinylchloride (PVC) self-adhesive tape 12.7 x 6-mm (1/2 x 1/4-in.) thick or as shown (can only be used in clean, dry conditions).

.3 Air Barrier Component Gasket: Closed-cell Ethylene Propylene Diene Monomer (EPDM) 8 mm (5/16 in.) diameter hollow tubular gasket with stapling flange. (For use when lumber is wet or in freezing weather or with the EASE system.)

2.4 Membranes

.1 Self-adhesive Rubberized Asphalt Membrane: Composite sheet of rubberized asphalt integrally bonded to a film of cross-laminated polyethylene that is a minimum of 1 mm (1/32 in.) thick, for peel and stick application.

.2 Primer and mastics as recommended for application by the manufacturer.

.3 Rubber Membrane: EPDM rubber membrane 1.6 mm (1/16 in.) thick.

PART 3–EXECUTION

3.1 Preparation of Joint Surfaces

.1 Examine joint sizes and conditions to establish correct depth-to-width relationship for installation of back-up materials and sealants.

.2 Remove harmful substances, such as dust, rust, oil grease, and other matter which may impair work, from bonding joint surfaces.

.3 Do not apply sealants to joint surfaces treated with sealer, curing compound, water repellent or other coatings unless tests have been performed to ensure compatibility of materials. Remove coatings as required.

.4 Ensure joint surfaces are dry and frost-free.

.5 Prepare surfaces in accordance with the manufacturer's directions.

3.2 Priming

.1 Where necessary to prevent staining, mask adjacent surfaces before priming and caulking.

.2 Prime sides of joints in accordance with the sealant manufacturer's instructions immediately prior to caulking.

3.3 Back-up Material

.1 Apply bond breaker tape where required according to the manufacturer's instructions.

.2 Install joint filler to achieve correct joint depth and shape.

3.4 Sealant Application

.1 Sealant

.1 Apply sealant in accordance with manufacturer's instructions.

.2 Apply sealant in continuous beads.

.3 Apply sealant using a gun with the proper size nozzle.

.4 Use sufficient pressure to fill voids and joints solid.

.5 Form the surface of the sealant with a full bead that is smooth, free from ridges, wrinkles, sags, air pockets and embedded impurities.

.6 Tool exposed surfaces to give them a slightly concave shape on exposed joints.

.7 Remove excess compound promptly as work progresses and upon completion.

.2 Curing

.1 Cure sealants in accordance with the sealant manufacturer's instructions.

.2 Do not cover up sealants until proper curing has taken place.

.3 Cleanup

.1 Clean adjacent surfaces immediately, and leave work neat and clean.

.2 Remove excess and droppings as work progresses, using recommended cleaners.

.3 Remove masking tape after initial set of sealant.

3.7 Gasket and Glazing Tape Application

.1 Install gaskets and tape in accordance with the manufacturer's instructions.

.2 Staple the gasket or tape at 300 mm (12 in.) o.c. to maintain it in place while abutting materials are installed.

.3 Ensure that gasket or tape is compressed by the installation of abutting materials.

3.8 Membrane Application

.1 Install membranes where shown and in accordance with the manufacturer's recommendations.

PART 1–GENERAL

1.1	Related Work Specified Elsewhere	.1	Sealants, Gaskets and Air-Barrier Membranes–Section 07900
1.2	Reference Standards	.1	Do work, except where specified otherwise, to ASTM C754 Specification for Installation of Steel Framing Members standards.
1.3	Examination	.1	Work is not to commence or continue unless a minimum temperature of 13°C (55°F) is maintained in the building.
1.4	Protection	.1	Before commencing work, protect all adjacent finished surfaces to save them from damage.

PART 2–PRODUCTS

2.1	Materials	.1	Gypsum board shall be standard and Type X in thicknesses shown on the drawings eased edge gypsum core with manila finished paper faces and shall comply with ASTM C840 Specification for Application and Finish of Gypsum Panel Products standards.
		.2	Gypsum board at exterior walls shall be foil-backed in thicknesses shown on the drawings, eased edge gypsum core with manila finished paper face and shall comply with CSA A82.27-M1977 and with CGSB-51-33 M80 Type 1 standards for vapour-barrier permeability.
		.3	Reinforced tape shall be strong, cross-laminated fibre tape, perforated and lightly creased for corner application.
		.4	Prefill joint compound shall be a polyindurate material that hardens in two hours.
		.5	Joint-filling compound shall be ready-mixed, compatible embedding, filling and finishing compounds of a vinyl base formulation.
		.6	Acoustical caulking shall be a non-hardening water-based caulking as recommended by the gypsum board manufacturer.

.7 Drywall furring channels: 0.5-mm (0.018-in.) core thickness galvanized steel channels for screw attachment of gypsum board.

.8 Nails, screws and staples must comply with ASTM C-754 standards.

.9 Laminating compound must comply with ASTM C-754 standards and be asbestos-free.

.10 Casing beads and corner beads: 0.5-mm (0.018-in.) base thickness commercial grade sheet steel with Z275 zinc finish perforated flanges; one piece length per location must comply with the standards of ASTM A924 or ASTM A924M, General Requirements for Steel Sheet Metallic-coated by Hot Dip Process and ASTM A653 or ASTM A653M, Specification for Steel Sheet Zinc-coated (galvanized) or Zinc Iron Alloy-coated Galvanealed by Hot Dip Process).

PART 3–EXECUTION

3.1 Fire-rated Gypsum Board Systems

.1 Fire-rated gypsum board systems shall be constructed in accordance with the requirements of the NBC and applicable ULC requirements.

.2 Finish gypsum board joints in attic fire separations and fire stopping with joint tape and one layer of compound. Sanding not required.

3.2 Air-Barrier Gasket Installation

.1 Do not commence gypsum board installation until air barrier gaskets are installed and inspected.

.2 Report any defects or discontinuities in gasketing, and obtain correction before proceeding with the work of this section.

.3 Exercise care to ensure that gaskets are not displaced or damaged during the work of this section.

.4 Observe screw spacing and ensure that gaskets are adequately compressed along their full length.

3.3	Air-Barrier Sealant Installation	.1	Apply air-barrier sealant in accordance with Section 07900.
		.2	Apply sealant in a continuous minimum 6-mm (1/4-in.) bead to top and bottom plates and as shown. Apply additional sealant where irregularities may prevent the full bedding of the gypsum board and to ensure a full seal between the board and framing.
		.3	Install gypsum wallboard immediately after sealant.
		.4	Observe screw spacing and ensure that the sealant is compressed along its full length.
3.4	Gypsum Board Application	.1	Do not apply gypsum board until bucks, anchors, blocking, electrical and mechanical work is approved.
		.2	Apply a single layer of gypsum board to furring or framing using screw fasteners. Maximum spacing of screws is 200 mm (8 in.) on centre (o.c.).
		.3	Provide additional layers where indicated.
		.4	Gypsum board on all exterior walls and interior partitions shall extend past finished ceilings to the underside of roof trusses except where shown otherwise.
3.5	Installation of Accessories	.1	Erect accessories straight, plumb or level, rigidly and at the proper plane. Use full-length pieces where practical. Make joints tight, accurately aligned and rigidly secured. Mitre and fit corners accurately, free from rough edges. Secure at 150 mm (6 in.) o.c.
		.2	Install corner beads on all external corners.
		.3	Install casing beads at all junctures not treated with joint finishing, at the full perimeter of suspended ceilings and at all free edges of gypsum board.
3.6	Installation of Gypsum Board Joint Treatment	.1	All visible and concealed junctions of gypsum board panels shall be taped and filled in accordance with the following.

.2 Joint compounds shall be mixed in accordance with the manufacturer's instructions and ASTM C840, Specification of Application and Finish of Gypsum.

.3 Prefill abutting rounded edges of eased-edge gypsum board with pre-filled compound, leaving a depression for tape.

.4 Apply reinforcing tape, embedding it in joint compound, and fold it and embed all angles to provide a true angle.

.5 A filling coat shall be applied over the embedding coat to fill board tapers flush with the gypsum board surface. On joints with no taper, the fill coat shall cover the tape and feather out at least 100 mm (4 in.) on either side of the tape.

.6 A finishing coat shall be applied to the fill coat and feathered to a smooth uniform finish.

.7 Where necessary, sand between coats and following the final application of compound to provide a smooth surface.

.8 Fill screw-head depressions with joint and taping compounds to bring them flush with the adjacent surface of gypsum board so as to be invisible when the painting is completed.

CHAPTER 9

QUALITY CONTROL

There are as many definitions of quality as there are roles in the building process. Take, for example, a housing project initiated by a non-profit housing authority. The roles of the parties and their definitions of quality would be as follows:

Owner

The owner would feel quality had been achieved if the finished construction was fit for the intended purpose and had been built within the agreed budget.

Designer

The designer would be satisfied with the quality of the building if it conformed to the requirements of the owner, the codes and the prevailing state of the art on the stated performance requirements.

Contractor

The contractor would define quality as the strict adherence to plans and specifications.

Inspector

The inspector would judge that the building was one of quality if the contractor had adhered as closely as possible to the standards established in the plans and specifications.

Facilities Management

Facilities management personnel would believe they were working in a quality building if it provided acceptable and predictable performance.

RESPONSIBILITIES

Quality starts with the owner. The owner should give the designer the following information:

- the intended purpose of the building,
- the expectations regarding the life span of building components,
- maintenance levels acceptable to the user and
- a construction budget consistent with the above expectations.

The owner is responsible for the quality of this information.

Through drawings and specifications, the designer defines how the quality of the finished building will meet the owner's expectations. The designer should ensure that drawings and specifications

- comply with building codes,
- follow current best practice,
- meet the agreed budget and
- fulfil the owner's expectations.

The drawings and specifications convey to the contractor the quality of the product that the owner intends to have. The responsibility for the quality of this information rests with the designer.

The contractor is responsible for ensuring that the building is constructed in accordance with the designer's plans and specifications. The contractor should have systems in place to

- control compliance of the work to drawings and specifications,
- report changes and seek approval of changes by the designer when compliance is not possible and
- co-ordinate and define roles of the different trades involved in the construction.

Much of the residential construction in Canada is single-family housing built by developers. The developer in these circumstances is the project initiator or owner. The developer's marketing branch may develop the detailed criteria for the project. The role of designer may be filled by an independent firm of architects or by an in-house design team. The role of inspector will be filled by individuals in the developer's construction division, such as the site superintendent and the quality control or customer service department. In a small company, all of these roles could be played by a single individual.

Regardless of the type of development process or the size of organizations involved, the successful construction of the building envelope will depend upon each of the various roles being performed satisfactorily.

QUALITY CONTROL AND QUALITY ASSURANCE

Quality Control

The techniques and activities that are used to fulfil requirements for quality are defined as quality control. For example, testing materials and inspecting the installation are quality control measures.

Quality Assurance

Quality assurance comprises all the planned and systematic actions that provide confidence that a product or service will satisfy given requirements for quality (see "Steps for Quality Assurance" later in this chapter).

Quality assurance must begin at the start of the project; quality cannot be obtained after the work is complete. If the completed work is substandard, those responsible for it have three alternatives:

- accept the substandard product,
- repair the product or
- replace the product.

Replacing a finished building is usually not an option. The other two alternatives may often be detrimental to the project. It is therefore essential to establish a system for quality control right at the start of a project and maintain it through to the end.

INSPECTION

Inspection refers to review of work to determine if it meets the standards. Those standards are detailed in the plans and specifications. Inspection may include the following:

- visual observation of material or methods,
- quantity measurement,
- testing of material properties,
- testing of assemblies and
- a review of quality assurance procedures.

Architects and engineers usually avoid the word "inspection," for it implies legal responsibilities beyond those which most architects, engineers or their insurers find acceptable. Architects and engineers use the term "review."

There are various types of inspectors with different types and levels of responsibility on a construction site. Projects with an independent designer may have several inspectors:

- a designer's or owner's inspector
- a contractor's inspector
- a municipal building inspector

The roles of each inspector should be made clear to all parties.

The designer's inspector does not ensure that the work is carried out in accordance with plans and specifications. Instead, the duty of the designer's inspector is to visit the site periodically to review the work and bring any noted deficiencies to the attention of the contractor and the owner.

The owner or developer may engage a specialist or retain the designer's inspector full-time to provide inspections over and above the general review provided by the designer.

The duty of the contractor's inspector is to review the work daily and receive the comments of the designer's and owner's representatives to ensure that deficiencies are corrected as the work proceeds.

STEPS FOR QUALITY ASSURANCE

1. Design drawings and specifications should clearly show the location, materials and standards of workmanship for the assembly.
2. Any special or extraordinary details should be discussed with an experienced contractor to be sure that the details are buildable.
3. The specification should require that, before the work commences, each trade must provide mock-ups of its work, incorporating repetitive details. These should initiate discussion so that potential difficulties and problems are resolved in advance of construction on a large scale. This type of exercise reveals the need for co-operation between specific trades. Mock-ups, whether incorporated into the final work or not, set the standard level of quality against which all subsequent work will be judged. The accepted mock-ups should be retained for reference.

4. Include requirements in the specification that samples be submitted for review before orders for materials are placed. Once a sample is found to be acceptable, it is kept on site for reference and comparison to the delivered material.
5. Require that shop drawings be included in the specifications for premanufactured items. The inspectors should confirm that applicable shop drawings are reviewed expeditiously, and they should verify that the contractor works from a reviewed set.
6. Before starting construction, hold a pre-construction meeting to review the following:
   - inspection and testing procedures,
   - submission of shop drawings,
   - construction sequencing and co-ordination of trades,
   - timing of inspections,
   - the contractor's methods of quality control,
   - the construction of a mock-up and
   - the submission of samples.
7. The inspectors should confirm that all the required permits and inspections needed to comply with local, regional, provincial and federal regulations have been arranged. Inspectors should be aware of the pertinent aspects of all applicable codes and ensure that construction is proceeding in accordance with them.
8. Where special inspection and testing is required, inspectors should ascertain that arrangements are made at the appropriate time, that the representatives of the testing companies are on site when required to carry out the tests and that the test results are reported expeditiously.
9. The contractor's inspector should review the work every day and ensure that the standards of quality as set out in the construction documents, including addenda, change orders and site instructions, are being maintained. The owner's inspector should visit the site periodically to review the construction. Any deficiencies observed should be pointed out in writing to the contractor and the owner. The contractor's inspector should ensure that the deficiencies pointed out by the owner's inspector are corrected. On subsequent visits, the owner's inspector should review the previously discovered deficiencies for evidence that they have been corrected.

SITE INSPECTION CHECKLIST

The following is a general checklist. Specific designer's and builder's checklists are provided with details in Chapter 8.

GENERAL

1. Read the specifications.
2. Study the drawings and details.
3. Review applicable code requirements.
4. Check that required permits have been obtained.
5. Know which air-barrier system is being used.

MATERIALS

1. Approve samples.
2. Inspect materials on delivery for compliance with specifications.
   a) Is the lumber the specified grade?
   b) Are the insulation materials as specified and in their original packaging, undamaged and dry?
   c) Are sealants, gaskets and vapour-barrier materials as specified?
3. Approve mock-ups.
4. Check storage, handling and protection of materials to ensure that applicable standards are met and damage to materials is prevented.
5. Establish procedures for testing and special inspections.

CONSTRUCTION CONDITIONS AND CO-ORDINATION

1. Log weather conditions affecting performance or progress.
2. Ascertain that the trades are working together and with regard to each other's requirements.
3. Before each trade starts work, examine the work upon which that trade's task depends. If corrective work is necessary, it should be done before the next trade begins. Ascertain that a qualified representative of the trade in question has accepted the previous work.

SUBSTRUCTURE

1. Are lines, layout and formwork correct?
2. Review concrete test results for compliance with specifications.
3. Is the concrete protected from freezing?
4. Verify the following:
   - the spacing of anchor bolts
   - the sealing of tie holes
   - the presence of dampproofing and a drainage system
5. Verify the installation of the air-barrier system or the sill gasket at the sill plate.
6. Is the foundation free of cold joints, honeycombing or other defects which would impair structural performance or water resistance?

SUPERSTRUCTURE

1. Verify that structural elements conform to plans:
   - size and spacing of joists and studs
   - thickness of sheathing
   - layout of trusses
   - fastener spacing
2. Verify adequate bearings for joists, lintels, beams and trusses.
3. Ensure that damaged or twisted joists and studs are repaired or replaced and will not affect the installation of finishes.
4. Confirm that joints in sheathing have been sealed in accordance with specifications.
5. Check the installation of firestopping and blocking for the attachment of fixtures and accessories.
6. Check that gaskets are continuous and correctly installed.

CLADDING

1. Is the sheathing membrane correctly installed?
2. Verify the presence of corner closures and compartmentation of the masonry cavity or strapping space behind the siding.
3. Confirm the installation of flashings and the wall drainage system.
4. For brick veneer walls, confirm the following:
   - correct width of cavity
   - spacing of veneer ties
   - cavity free of mortar droppings
   - free-draining weepholes at correct spacing
   - properly tooled joints

INSULATION, AIR-BARRIER SYSTEMS AND FINISHES

1. Confirm the following for insulation installation:
   - insulation accurately cut to fit neatly around irregularities
   - all cavities and spaces filled completely to avoid air spaces
   - correct depth of attic insulation
2. Verify sealants or gaskets for continuity and accuracy of installation.
3. Confirm the presence of specified gaskets or sealants at electrical outlets and envelope penetrations.
4. Verify the presence and continuity of the vapour retarder.
5. Confirm the following for drywall installation:
   - correct spacing of fasteners
   - floating joints correctly constructed at the partition and truss interface
   - continuity of the drywall and air-barrier membrane at partitions and other interruptions of the exterior wall
   - all joints and fasteners are correctly sealed (including in unexposed locations)

AIRTIGHTNESS

Verify that the airtightness of the building envelope meets the required standard. The home-owner can then be assured of obtaining

- cost savings due to energy efficiency,
- improved occupant comfort and
- increased envelope durability due to less moisture migration into the walls and less wetting of the walls due to the application of the rainscreen concept.

TEST PROCEDURES

The test procedure to be followed is "Determination of Airtightness of Building Envelope by the Fan Depressurization Method," CAN/CGSB2-149.110-M85.

It is common to test a home after the air-barrier elements have been completed and once again when the finishes are installed. If deficiencies are found above the prescribed limit, then they must be investigated by the builder and repaired.

MULTI-UNIT BUILDINGS

On multi-unit projects the following procedures may be followed.

Option 1

The envelope will be progressively tested to determine air leakage, structural performance of the air barrier, thermal-barrier discontinuities and water leakage, as the individual areas are substantially completed. An envelope assembly should be tested in some areas, but need not be tested everywhere, as long as construction reviews certify that other areas are constructed to the same quality of construction. Following substantial completion, the whole building will be tested.

Option 2

The building envelope will be tested through an on-site mock-up. The construction of the mock-up will be described in the architectural drawings. If the air leakage, structural performance of the air barrier and the thermal barrier conform to the prescribed criteria, then the construction can proceed. The actual construction should closely follow the quality of construction of the mock-up. If the performance does not meet requirements, the construction quality must be improved until the performance criteria are attained.

If air leakage criteria form part of the construction documents and contractual responsibility of the builder, then the builder must be fully briefed on what is expected. Members of the construction team will also have to be briefed about

- the design objective,
- the performance requirements,
- which tests will be conducted and when and
- the acceptable level of quality.

AIR LEAKAGE STANDARDS

National standards are now being put in place for air leakage through the building envelope. The National Research Council of Canada (NRC) Building Practice Note (BPN) 54 recommends a maximum leakage of 0.1 L/s-m^2 (0.002 gal./s.-ft.^{2}) at an air pressure differential of 75 Pa.(0.01 lb./in.^{2}) for residential occupancies. This recommendation has been used as a criterion for evaluating air-barrier assemblies in laboratory tests carried out for CMHC. Many of the systems and detailed assemblies tested have performed satisfactorily.

When blower door testing is done on a completed dwelling, air leakage will occur not just through the envelope but also through doors, windows, fans, flues and sumps. The air leakage rate will therefore be higher than 0.1 L/s-m^2 (0.002 gal./s.-ft.^{2}) @ 75 Pa.(0.011 lb/in.^{2}). Just how much higher is not yet known.

The R2000 Home Program incorporated an air leakage standard for all homes built under its program. R2000 is a voluntary program administered by the Canadian Home Builders' Association in co-operation with Natural Resources Canada.

The R2000 technical requirements permit 1.5 air changes per hour (AHC) at 50 Pa (0.007 lb./in.^{2}) for the entire volume of a house. Alternately, a normalized leakage area (NLA) of 0.7 cm^2/m^2 (0.01 in.^{2}/ft.^{2}) may be used. This NLA rate equates to a leakage rate of 0.64 L/s-m^2 (0.013 gal./s.-ft.^{2}) @ 75 Pa.(0.01 lb./in.^{2}), which is six times larger than the NRC recommended level. It must be kept in mind that the R2000 air leakage standard cannot be directly compared to the NRC recommendation, because the R2000 figure includes leakage through doors, windows, fans and flues.

The 1995 National Building Code of Canada now requires that for buildings governed by Part 3, sheet and panel air-barrier material have an air leakage rate of not greater than 0.02 L/s-m^2 (0.00041 gal./s-ft.^{2}) @ 75 Pa. (0.01 lb./in.^{2}). It does not give a criterion for acceptance of the overall assembly, nor does it give numeric criteria for air barriers in single-family homes and other buildings governed by Part 9 of the code.

The National Energy Code for Houses 1995 requires that an air barrier system be incorporated into the building envelope. It states that any location where there is the possibility of air leakage through the envelope shall be caulked, gasketed or otherwise sealed. In the absence of such seals, the house shall be constructed so that its building envelope has a normalized leakage area that does not exceed 2.0 cm^2/m^2 (0.029 in.^{2}/ft.^{2}) This corresponds to a leakage rate of 1.8 L/s-m^2 (0.037 gal./s.- ft.^{2}) @ 75 Pa.(0.011 lb./in.^{2}).

Additional Air-Barrier Information

Further information on air-barrier performance and testing can be found in the CMHC publication *Commissioning and Monitoring the Building Envelope for Air Leakage*, report number 33127.02, November 29, 1993.

CHAPTER 10

MAINTENANCE AND REPAIR

One-hundred-year-old wood frame homes are common throughout Canada. However, the envelope components have varying life expectancies and maintenance cycles. Table 10-1 provides the estimated life expectancies of materials exposed to normal weathering.

Table 10-1: Estimated Life Expectancy of

Item	Estimated Life in Years
Wood Frame Structure	indefinite
Exterior Sealants	4 to 10
Paint and Stain	4 to 6
Air-Barrier Sealants	15 to 25
Drywall	40 or more
Metal Siding	25
Vinyl Siding	25
Wood Siding	25 or more
Brick Veneer	50 or more
Metal Copings and Flashings	25
Windows	25 or more
Asphalt Shingles	15 or more

Since wood is an organic material, which is subject to attack by fungus, rot and insects (termites and carpenter ants), maintenance and protection of all elements are essential to the long-term performance of the wood components.

All of the items in Table 10-1 require regular inspection and maintenance to achieve the listed life expectancies.

Maintenance of wood frame buildings means ensuring that the materials and systems are kept in a condition that will allow them to perform in the manner for which they were designed. These are examples of maintenance tasks:

- repainting
- repointing of brick mortar joints
- replacing sealants at windows, doors, joints, flashings, etc.
- repair or replacement of windows
- repair or replacement of siding
- repair and replacement of air-barrier seals where accessible (such as at the joints between the gypsum board and floor sheathing or at wall sheathing when replacing siding)

GENERAL INSPECTION

A thorough inspection and maintenance program is recommended as an inexpensive way to extend the life of the building. The inspector should

- become familiar with the existing construction,
- obtain further information about the envelope through review of available design, drawings, specifications and manufacturers' instructions and
- carry out a monitoring program that includes a regular (at least yearly) visual review of all areas of the building that are accessible through access openings.

Seasonal inspections allow inspectors to observe the behaviour of the different building materials in various weather conditions. Decisions on what maintenance needs to be done and when it can be undertaken can be based on information obtained in the monitoring program. Timely implementation of maintenance work is the key to prolonging a building's life.

An inspection checklist appears in Table 10-2 as a possible guide for these regular inspections.

MAINTENANCE PROCEDURES

Regular maintenance will include the following procedures.

Brick Veneer: Replace damaged units, and repoint mortar joints.

Sealants: Some types of joints will permit the application of additional sealant over split caulking. Where partial delamination has occurred, the material may be cut out and replaced where required. Full replacement involves cutting out all the old sealant and installing new backer rods and sealant.

Siding: Replace damaged or split pieces. Renew the finish when required.

Stucco: Repair cracks or chips using stucco plaster or appropriate sealant. Where stucco has deteriorated, its life may be extended by applying an acrylic coating.

Paint: Remove blistered or peeling paint to create a smooth base, and repaint.

Roof Shingles: Replace damaged or missing shingles. When shingles require replacement, a new layer may be installed over the existing shingles. Subsequent layers will require the removal of the existing shingles.

AIR-BARRIER MAINTENANCE

Little field data exists on the life expectancy and maintenance of air barriers. Assessment of the condition of the air barrier can be made by carrying out the Fan Depressurization Test used when the system is commissioned. Where the interior drywall forms an air barrier, a visual check can be made of its general integrity.

Maintenance of a gypsum-board air barrier will consist of repairing all perforations and cracks.

The baseboard may require removal to allow the application of new sealant to the joint between the gypsum board and the floor sheathing.

Where an exterior air barrier sheathing is used, it must be inspected and repaired in conjunction with recladding. When the air barrier is exposed, an assessment of the necessary repairs can be made.

REPAIR

Despite the best efforts to maintain the building envelope, situations will arise when deterioration and damage occur. This is usually indicative of a problem requiring more intensive investigation than the earlier general inspection indicated. Whatever the problem, its effects are usually identified before the problem is detected. Before making repairs to the obvious deterioration, understand and eliminate the factors causing it.

INVESTIGATION

At times the problem is self-evident, but if not, either non-destructive or destructive testing should be undertaken to identify it.

Examples of non-destructive tests are listed below:

- electrical conductivity (water detection)
- infrared thermographic (heat loss or air leakage)
- monitoring
- photography
- air leakage testing

Before conducting any of the above tests, consider the necessity for them in relation to the amount and value of the information to be obtained. The non-destructive tests may provide some indication of a problem but must usually be verified by destructive investigation. It is sometimes more cost effective to proceed directly to a destructive verification. Once the source of the problem is discovered, measures can then be taken to effectively remedy both the cause and its effects.

Table 10.2: Building Inspection Checklist

	NORTH	SOUTH	EAST	WEST
Brick Veneer				
Cracked Unit				
Efflorescence				
Missing/Clogged Weepholes				
Deteriorated Mortar Joints				
Cracked Mortar Joints				
Spalled Units				
Stains				
Water Penetration				
Flashing				
Bent				
Missing				
Sealants				
Splits				
Peeling				
Missing or Incomplete Sections				
Surface Bubbling				
Siding				
Split				
Deformed/Warped				
Loose				
Finish Deteriorated				
Stucco				
Cracked				
Chipped				
Paint				
Peeling				
Blistering				
Roof Shingles				
Missing/Broken				
Cupped/Deteriorated				
Fascias and Soffits				
Bent or Displaced				
Finish Deteriorated				

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APPENDIX A

CAD USAGE

OVERVIEW

The CMHC Wood Frame Envelopes Best Practice Guide *CAD Detail Library* is a collection of drawing files created with AutoCAD™ showing construction details. The details presented in Chapter 7 of this guide are included as CAD drawing files on the accompanying disk. The .DWG drawing files are compatible with all versions of AutoCAD starting with Release 11. The .DXF files were created with AutoCAD Release 12. If you are not using AutoCAD software, consult your CAD software manual on how to import AutoCAD .DXF files.

The *CAD Detail Library* does not require any special configuration. The detail drawings require no more memory or disk storage than if you had created them yourself.

The details are designed to be used without modification. Each library detail has been prepared to allow you to simply insert a detail onto a drawing sheet. You may explode and modify the details as required and use their components as blocks in the same way as you would use a block you created yourself. You may wish to save your modified versions as new, separate drawing files for future use.

To conserve space on your hard disk, you may access the *CAD Detail Library* from the CD-ROM. However, all or part of it may be copied to your hard disk if desired.

The first character of each library file name is the Best Practice Guide code for the material in question. The next three characters are a short form of Best Practice Guide (BPG). The last four numbers are detail group identification numbers. The file names have the extension .DWG or .DXF. For example:

File name: WBPG0026.DWG

BPG Code:
- W: Wood Frame
- M: Masonry
- F: Flashing

BPG: Best Practice Guide

0001: Detail Identification

CONVENTIONS USED

It is assumed that the user has a basic knowledge of CAD software, and therefore no attempt will be made here to explain "layering," "fonts," "colours," and other basic drawing conventions associated with most CAD software packages.

The entities comprising the details are drawn on various layers depending on what they are. Each entity is assigned a specific colour and specific line type. Elements are assigned colour "BY LAYER."

The following layer names are used in the BPG *CAD Detail Library*:

Name	Description	Colour
W-TEXT-1	Text	2
W-GYPS-1	Gypsum Board	9
W-GYPS-2	Gypsum Board	12
W-CONC-2	Concrete	7
W-BRCK-1	Brick	1
W-BRCK-2	Brick	12
W-BRCK-3	Brick	4
W-BLCK-1	Concrete Block	8
W-BLCK-2	Concrete Block	12
W-GRADE	Grade	5
W-STEEL-2	Steel Reinforcing	2
W-INSUL-1	Insulation Patterns	11
W-INSUL-2	Insulation	8
W-METAL-2	Metal Flashing	7
W-MEMB-X (X = 1 or 2 or 3, etc., depending on the drawing)	Membrane (Various)	Colour varies by drawing and membrane type
W-HATCH	Hatching Patterns	11
W-WOOD-1	Wood (Boards)	12
W-WOOD-2	Wood (Framing, Blocking)	7

Recommended Pen Widths for Plotting

Colour	Pen Width
1 (Red)	0.09 mm (0.0035 in.)
2 (Yellow)	0.013 mm (0.0005 in.)
3 (Green)	0.70 mm (0.028 in.)
4 (Cyan)	0.50 mm (0.020 in.)
5 (Blue)	0.60 mm (0.024 in.)
6 (Magenta)	0.60 mm (0.024 in.)
7 (White)	0.35 mm (0.014 in.)
8 (Grey)	0.18 mm (0.007 in.)
9 (Thin Red)	0.18 mm (0.007 in.)
10 (Thin Gold)	0.25 mm (0.010 in.)
11 (Thin Green)	0.01 mm (0.0004 in.)
12 (Thin Cyan)	0.25 mm (0.010 in.)
13 (Thin Blue)	0.50 mm (0.020 in.)
14 (Thin Magenta)	0.35 mm (0.014 in.)
15 (Thin Grey)	0.18 mm (0.007 in.)

Other useful information products from Canada Mortgage and Housing Corporation.

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